MACHINERY

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METHODS USED IN ERECTING PLANERS

FOUNDATIONS, ALIGNMENT, SQUARING UP, ERECTING COUNTERSHAFTS, ETC.

BY EDWARD K. HAMMOND*

Edward K. Hammond†

DISAPPOINTMENT is sometimes experienced in the performance of new machinery, owing to its failure to produce work of the standard expected. In most cases, however, the machine itself is quite capable of properly doing the work for which it was sold, and an investigation by an expert will usually show the trouble to be due to one of two general causes; the machine is either improperly used, or it has been incorrectly set up. Either error will make production of accurate work impossible, and incorrect methods of setting up a machine will also often cause it to be seriously damaged. It is the purpose of this article to explain the correct methods of setting up a planer, the information presented being based upon methods developed by the Cincinnati Planer Co., Cincinnati, O.

In setting up machines of this type, the following requirements must be fulfilled. A solid foundation must be provided for the planer to rest upon. The bed must be true and set level upon the foundation and square with the lineshaft; it must bear evenly upon the foundation and be adequately supported by it. The cross-rail must be exactly parallel with the table. It will be evident to any machinist that a planer cannot give satisfactory results unless the table runs perfectly true and the cross-rail is parallel with it. The necessity for a solid foundation, upon which the planer bed is evenly supported, is just as important a factor in securing accurate work, although it is not so generally appreciated. Where a planer bed is not given adequate support, its weight will cause it to be sprung out of shape, and the inaccuracy of the ways which is produced in this way will manifest itself in the work produced on the machine.

The best practice is to set planers upon a concrete foundation and the Cincinnati Planer Co., in common with most reliable builders, furnishes foundation plans giving details for the construction which has been found suitable for the size of machine to be installed. Fig. 1 shows one of these foundation plans for a 62-inch x 62-inch x 14-foot Cincinnati planer. This plan calls for the use of leveling blocks between the planer bed and the foundation, one of these being illustrated in Fig. 2. The sliding members of these blocks are lubricated with graphite, to make sure that they will work smoothly, and by means

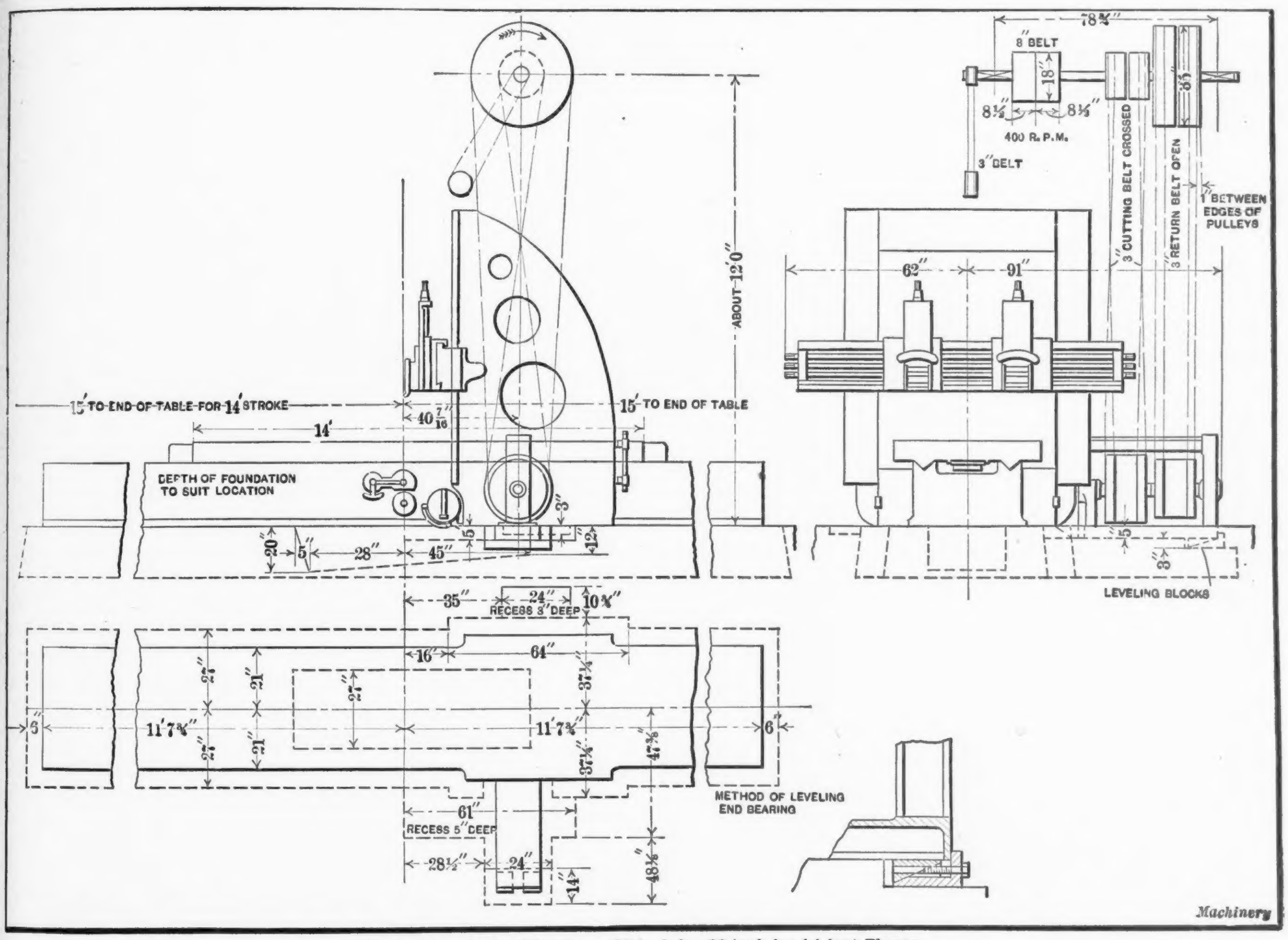

Fig. 1. Foundation Plan for a 62-inch by 62-inch by 14-foot Planer

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of the adjusting screws, each individual block may be set to exactly the required point to bring the planer bed to an accurate level. Where the planer has feet, these rest upon the leveling blocks, but where the bed extends right down to the foundation, the blocks are distributed in the way best suited to carry the weight of the bed and protect it from being strained at any point. Average conditions require leveling blocks in the foundation at intervals of four feet. These blocks not only provide a rapid and accurate method of leveling, but also make it possible to correct a considerable amount of error that may be found in either the planer bed itself or in the foundation, thus bringing the machine back to an accurate level in either case.

In preparing this type of planer foundation, the concrete is filled in to within about eight inches of the floor line. The

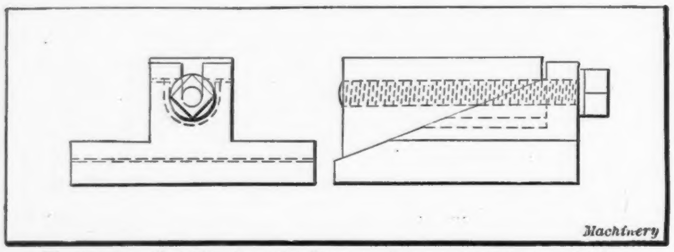

Fig. 2. Leveling Block of the Type used in a Concrete Foundation

leveling blocks are then placed in position and carefully adjusted with a long straightedge so that tissue paper will be held tightly on any block when the straightedge is passed from one position to another. After the blocks have been placed in position with the required degree of accuracy by this adjustment, the concrete is filled in almost to the level of their upper faces, spaces being left to allow access to the adjusting screws. These spaces should be provided with covers to keep chips and dirt away from the screws.

The use of heavy concrete foundations and leveling blocks of this type make the initial cost of installation rather high, but it is possible, in this way, to secure a higher degree of accuracy in planer work than is usually considered practical. This increased accuracy permits the saving of a great deal of time in scraping the work after it has been planed. The time required to keep the planers themselves in proper working condition is also reduced when they stand upon accurate founda-

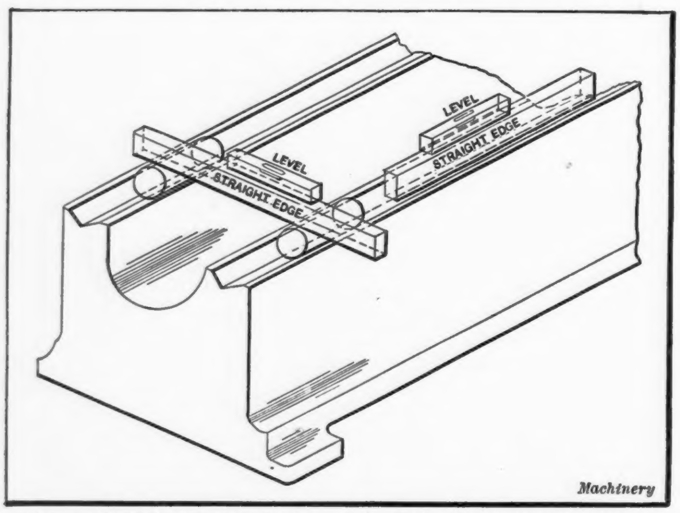

Fig. 3. Method of Testing the Level of a Planer Bed in Two Directions

tions, because all unnecessary strains upon the machines, due to lack of adequate support, are eliminated.

An idea of the efficiency of this form of foundation for a planer may be gathered from tests which have recently been made in the shops of the Norton Grinding Co., Worcester, Mass. After a year of constant use, the table of an 18-inch x36-inch planer with an 18-foot bed was tested with a 15-foot straightedge, and it was found that tissue paper could be held at any three points on the table, with the table in any position on the bed. When a planer is able to meet such a severe test, the claim for a greater accuracy in its output will be readily granted, as very few planers successfully meet such a test when mounted on any other form of foundation.

There has recently been considerable discussion concerning the advisability of bolting down planers to the foundation. The claim is made that a machine which is heavy enough to do its work well will not move at reversal, and the belt pull can never left it from the floor. Experience has shown that the only fastening necessary for a planer standing on a concrete foundation and leveling blocks, is to drill the plates and put in one-half-inch pins on each side of one or more pairs of legs, to prevent endwise sliding. In certain cases where this method of fastening was used, the pins were originally set so that they did not touch the planer feet, and the machine has never moved enough to bring them into contact. The use of foundation bolts was discarded on account of several objectionable features for which they are responsible. Among these the following may be mentioned: When a planer is bolted to a wooden floor and a heavy weight is placed near it, the planer is bound to follow any temporary settling of the floor which occurs; this sets up a strain in the entire planer. The same objection applies when permanent settling occurs in any form of planer foundation, and springing or deformation of the bed is bound to take place if it is bolted to the foundation at the time when the settling takes place. The pres-

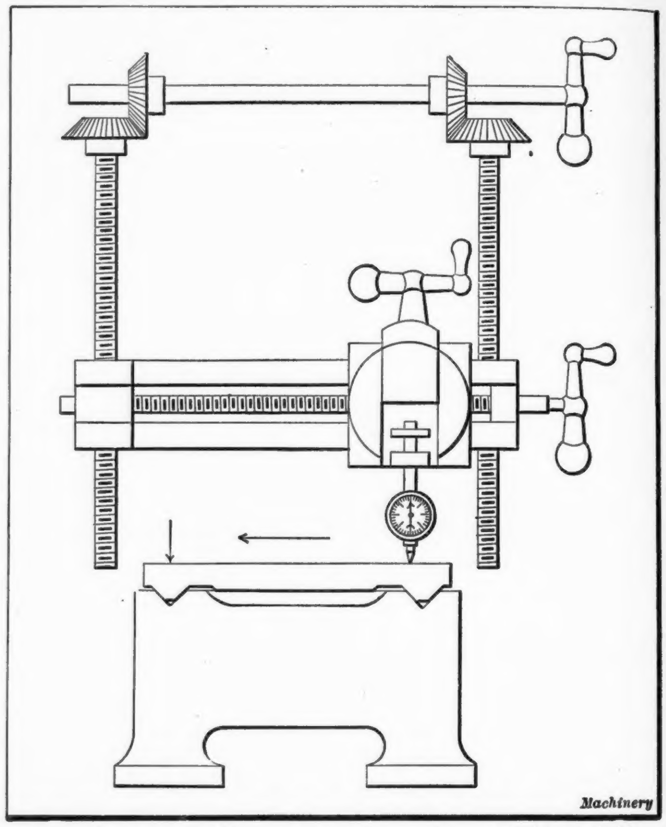

Fig. 4. Testing the Alignment of the Planer Cross-rail with the Table

ence of foundation screws also presents the possibility for careless workmen to attempt to use them to level the bed. This is obviously poor practice, because any leveling that is accomplished through the tightening of foundation screws, is done by springing the bed out of shape.

A More Simple Form of Foundation

A more simple method of supporting a planer consists of preparing a preliminary foundation upon which the machine is placed. Iron wedges or cedar shingles are then used to raise the bed to a height of about one inch above the level of the foundation, and also to bring it to a level position. A mortar is now made, consisting of one part of Portland cement to one part of sand, which is used to raise the foundation to the level of the bottom of the bed. Where this method of constructing a foundation is followed, care must be taken to tamp in the mortar firmly under the bed. A foundation of this kind is less expensive than the one previously described, but it is also far less serviceable in the long run.

Placing the Planer on the Foundation

In placing the planer on the foundation, care must be taken to have the bed set exactly square with the line shaft in order to provide for a proper operation of the driving belts. After this condition has been fulfilled, the bed must be ac-

curately leveled in both the lenghtwise and crosswise directions. This is done by removing the table and using a good spirit level to determine the direction in which the leveling blocks must be adjusted to bring the bed into the required position. If a level, which is long enough to reach across the bed is not available, a shorter instrument may be used on the top of an accurate straightedge which is parallel on both sides.

The beds of the planers built by the Cincinnati Planer Co.

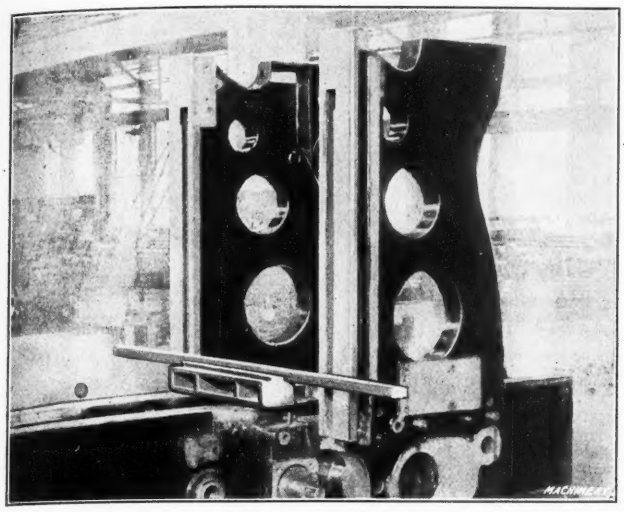

Fig. 5. Method of Bringing the Housings Square with the Ways

and many other firms, have the surfaces at the top of the Vs planed exactly parallel with the ways. If it is known that this method has been followed by the firm which built the planer that is being set up, these surfaces can be used as a support for the spirit level. Fig. 3 shows the proper method of procedure where the top surfaces of the bed have not been accurately lined up with the ways. In this case the ways themselves are used in leveling the bed. For making the crosswise adjustments, two cylindrical bars, of exactly the same diameter and of suitable size to fit in the Vs, are used as supports for the spirit level or straightedge. For the lengthwise adjustments, the level is set directly in the Vs. The bed is left a trifle high at the center, because the pressure of the tool and the weight of the housings come at this point; this causes a little more deflection and a slightly greater tendency for the foundation to settle. By observing the precaution of having the bed a little high at this place, the ways will, in the end, be brought to an accurate level.

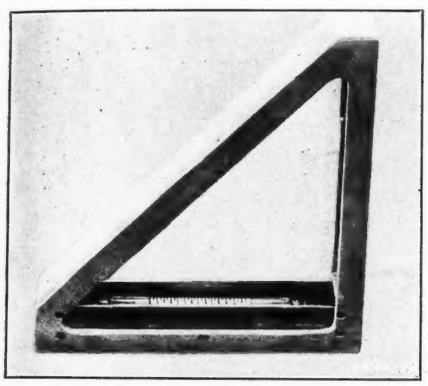

Fig. 6. Special Square used to Determine Vertical Alignment of the Housings

A series of tests should be made along the entire length of the bed to make sure that it is level in both lengthwise and crosswise directions. Such a series of tests should also be repeated at frequent intervals for some time after the planer has been set up, as there is a probability that the foundation will settle, thus disturbing the alignment. Where such settling is detected, the machine is easily brought back into position by means of the screws in the leveling blocks.

It is not necessary to level, in the lengthwise direction, a planer bed which only has legs at the ends, because the distance between the legs is never great enough to cause a deflection in the bed. Consequently, if the bed is a little high at either end, it will still plane straight, because the table will travel in a straight line and there is no tendency for its bearings in the bed to get out of alignment.

Special care, however, ought always to be taken in testing the lengthwise level in all other cases, as all planer beds do not have their ways scraped to a straightedge. Where the bed is merely scraped to fit the table, it insures a bearing, but does not show that the ways are straight, and in such cases, the provision of an absolutely level foundation is required to enable the bed to straighten itself out into proper alignment. When the bed has been brought to a satisfactory level, the Vs of both the bed and the table are thoroughly cleaned to remove grit and dirt, and the oil pockets in the bed are filled with a supply of good machine oil. The table is then replaced upon the bed and the next step is to see that the cross-rail is in proper alignment with the table. For this purpose, a distance rod or some form of surface gage is clamped in the planer tool-post to measure the distance between the rail and opposite sides of the table.

Fig. 4 shows the method of making these measurements with a dial test indicator, which has the advantage of showing the exact amount of any error that may be found in the alignment of the cross-rail. The same general method of procedure is followed with a distance rod; in this case, a piece of hard paper would be used as a feeler. The distance between the table and the cross-rail is measured first at one side of the table and then at the other, as indicated in the illustration. If this test shows the cross-rail to be out of alignment, the error is removed by adjusting the nuts on the elevating screws. These screws are a sliding fit in the bevel gears and carry fine threaded adjusting nuts which rest on the top of the bevel gears. By means of these nuts, the elevating screw at either side of the table can be raised sufficiently to bring the cross-rail parallel with the table. This adjustment should always be made by raising the low side of the rail. If the adjustment was made by lowering the high side of the rail, there would be a little backlash in the adjusting screws. This backlash would allow the rail to work out of the desired alignment with the table.

It was formerly considered necessary for a planer to plane off its own table after having been set up on the floor where it was to be used. Modern practice has discarded this method of procedure. The planers built by leading manufacturers plane their own tables before they leave the shops. Consequently, they require no further finishing, providing the bed has been set up as it ought to be. In fact, the practice of planing off a table is wrong, because if it is necessary to remove any error in the table by planing, it shows that the foundation is not properly leveled, and the trouble should be eliminated by adjusting the leveling blocks.

Additional Operations on Large Planers

Small and moderate-sized planers are usually shipped to the purchaser's plant fully assembled. In such cases the method of setting up which has been outlined puts the planer

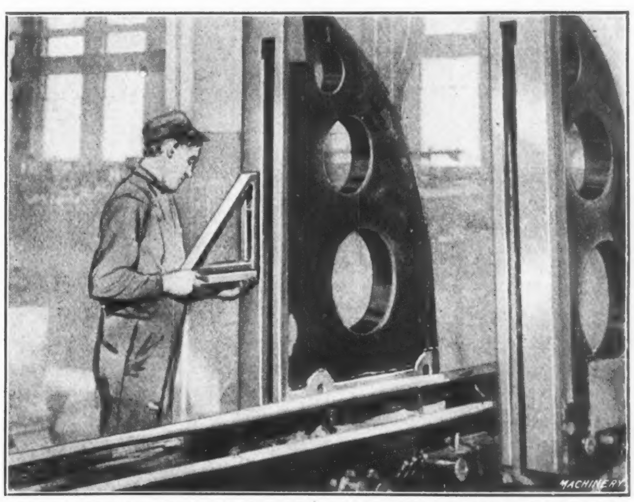

Fig. 7. Testing Vertical Alignment of Housing Parallel with the Bed

into condition to be belted to the countershaft; but in assembling large planers which have been taken down to facilitate shipment, or to make repairs on machines that have been damaged in transit, great care must be observed to bring the housings into proper alignment. After the bearings, shafts, and gearing are put into place in the bed, the housings are brought into position and tested to see that their

faces are square with the ways and that they are in the proper vertical alignment in both the lengthwise and crosswise directions.

The method of bringing the housings square with the ways is shown in Fig. 5. The fixture used for this purpose fits into the Vs and a straightedge is held by a shoulder as shown; the housings are then lined up with the straightedge. A special square shown in Fig. 6 is used to determine the vertical alignment of the housings. This square is fitted

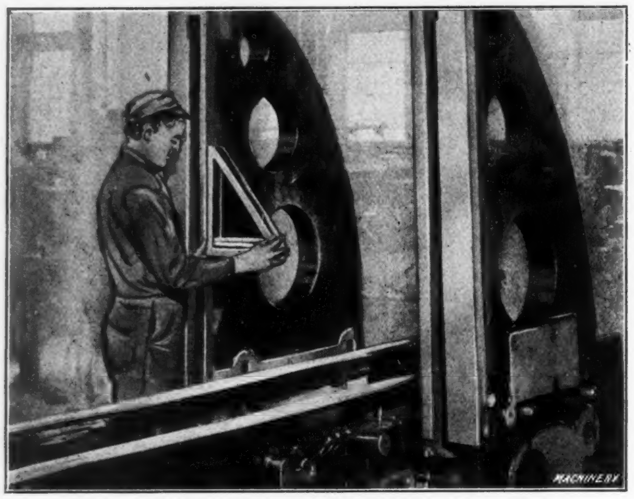

Fig. 8. Testing Vertical Alignment of Housing at Right Angles with the Bed

with a special spirit level which has been graduated to make each ⅛-inch space correspond to an error of 0.001 inch in 4 feet in the alignment of the housings. The method of using this square is illustrated in Figs. 7 and 8, where the alignment of the housings is being tested in two directions. The square is held against the face of one housing and the position where the bubble stops is noted. The square is then shifted to the corresponding face of the other housing and the position of the bubble is again noted. The same tests are made for the other pair of faces on the housings. If the position of the bubble is found to differ for either set of tests, the square shows the amount of error and the direction in which the adjustment must be made to bring the housings into proper alignment. When necessary adjustment has been made, so that any error which exists is within 0.001 inch in 4 feet, which corresponds to one graduation on the spirit level, the holes in the housings are reamed and they are then doweled into place on the bed. The cross-rail is next mounted in position on the housings and brought exactly parallel with the planer table, by the method previously described. The remaining parts of the planer are now assembled and the machine is then ready to be belted to the countershaft.

Erecting the Countershaft

In setting up the countershaft, care must be taken to have it perfectly level and parallel with the lineshaft; it must also be accurately located according to the requirements of the foundation plan, as shown in Fig. 1. This plan also gives instructions regarding which is the open and which the crossed belt. The importance of having the countershaft correctly located in relation to the planer lies in the fact that the belts will not shift properly if it is too far in front of or behind the proper position. After the countershaft is placed in position, the loose pulleys and hanger boxes must be given a copious supply of machine oil, and care should be taken to see that the pulleys and shaft turn freely. The collars on the shaft must be set to permit a little end play in the boxes, but not too much.

Some shops are in the habit of overlooking the superior driving and wearing powers of double belting in order to keep the first installation cost as low as possible. Economy in this direction is ill-advised, and double belting of the width specified in the foundation plan ought always to be used. The "cutting" belt, which is the crossed belt in most cases, should be crossed so that the side running back to the countershaft is on the inside next to the housing of the planer. The importance of this arrangement lies in the fact that the side of the belt operated on by the shifter forces the other side with it and enables the reversal to be made in less time than would otherwise be possible.

After all of the belting is in place, all of the pulleys and gearing in the planer should be rotated by hand, to make sure that everything runs freely, before the power is turned on. The gears should be given a good coat of heavy oil, and all of the bearings, loose pulleys, and oil holes must have a liberal supply of the best machine oil two or three times a day for the first week after the planer is placed in service. This precaution will often prevent serious wear while the machine is running itself into smooth running order. In the case of large machines, the further precaution of running them idle for a day or two before starting on heavy work should always be observed.

The time spent in putting new planers into proper operating condition is of little value unless care is taken to protect them from injury while in use. Consequently, some advice concerning the methods of protecting planers from damage will not be out of place in this article. In order to produce accurate work, the ways of a planer must be true, and, owing to their exposed position, special care must be taken to protect them from injury. Several methods are in common use. In planing short work, the ends of the ways may be covered with boards or canvass to keep chips and dirt out of them. A more elaborate method of securing protection for the Vs has been designed and patented by Mr. W. A. Thelin, foreman of the planer department of the Bullard Machine Tool Co., Bridgeport, Conn., where this method has been used for keeping the planers in good operating condition for a number of years.

Fig. 9 shows this device. The two spools at the end of the planer bed have strips of canvass wound on them which are slightly wider than the Vs. These strips are attached to the table, as illustrated, and as the table moves forward, the strips of canvass are unwound from the spools and keep the

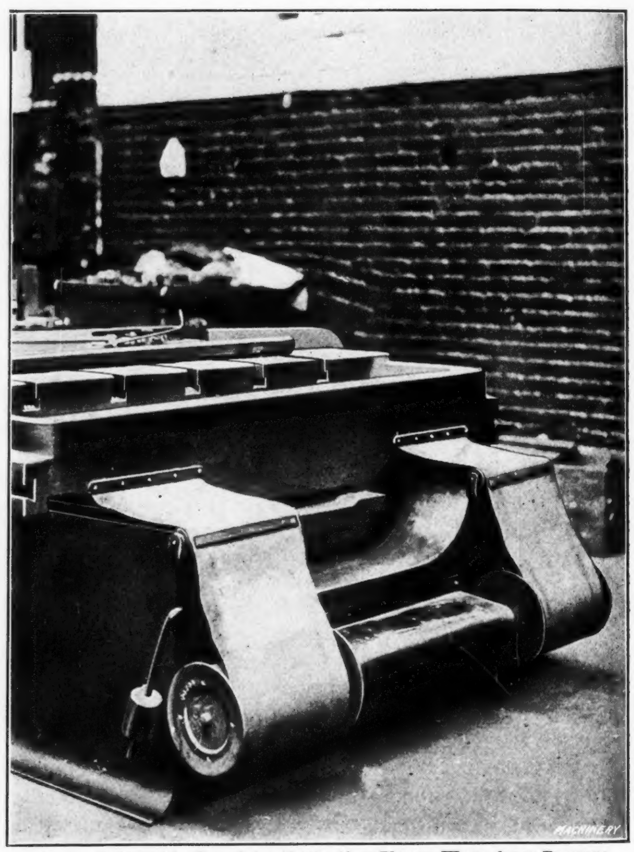

Fig. 9. Automatic Guard for Protecting Planer Ways from Damage

Vs covered. On the return stroke, the spools rewind the canvass strips through the action of a spring-actuated shaft on which the spools are mounted. Two rollers, carried on counterweighted arms, hold the canvass clear of the ends of the bed, and when the table comes forward to the end of the ways, the arms are swung down by means of blocks on the under side of the guards. An advantage in the use of these guards lies in the fact that they are equally available for all lengths of work and act automatically in protecting the ways from scoring or cutting without hindering the operator in any way.

Another form of planer protection consists of suspending a canopy of canvass over the machine. This prevents chips or dirt from dropping from the ceiling, or from overhead cranes, onto the planer ways, but does not offer protection to the machine from the chips which it is making, and care ought always to be taken to avoid brushing chips or dirt off the table into the ways, or to allow such material to collect around the bull wheel. A point ought always to be made of running the table out to the end of the bed, so that it completely covers the Vs and gearing, before starting to brush off chips or to clean out the T-slots.

Some mechanics do not realize how easily the shape of a planer table can be seriously altered. If they did, more care would be taken in placing heavy work in position. A planer table ought never to be used as an anvil or straightening plate, and care should be taken to prevent heavy castings from falling on it more often than is absolutely necessary. The blows caused by carelessness in handling castings that are being placed in position on the planer table not only cause bruises, but they have a slight peening action which changes the shape of the table more rapidly than is generally supposed. Damage of this kind may be guarded against by laying short boards on the table for the work to be lowered upon. These boards are then easily removed by raising the work first at one side and then at the other.

Care in setting up a machine and in caring for it after it has been placed in service are of equal importance in enabling it to continue to produce accurate work for a reasonable operating life. The methods outlined will be found to pay excellent returns on the time spent in following them, in the form of a decrease in the time required to keep the planers in good working order, in an increase in the accuracy of the planer work, and in an increase in the length of the operating life of the machines.

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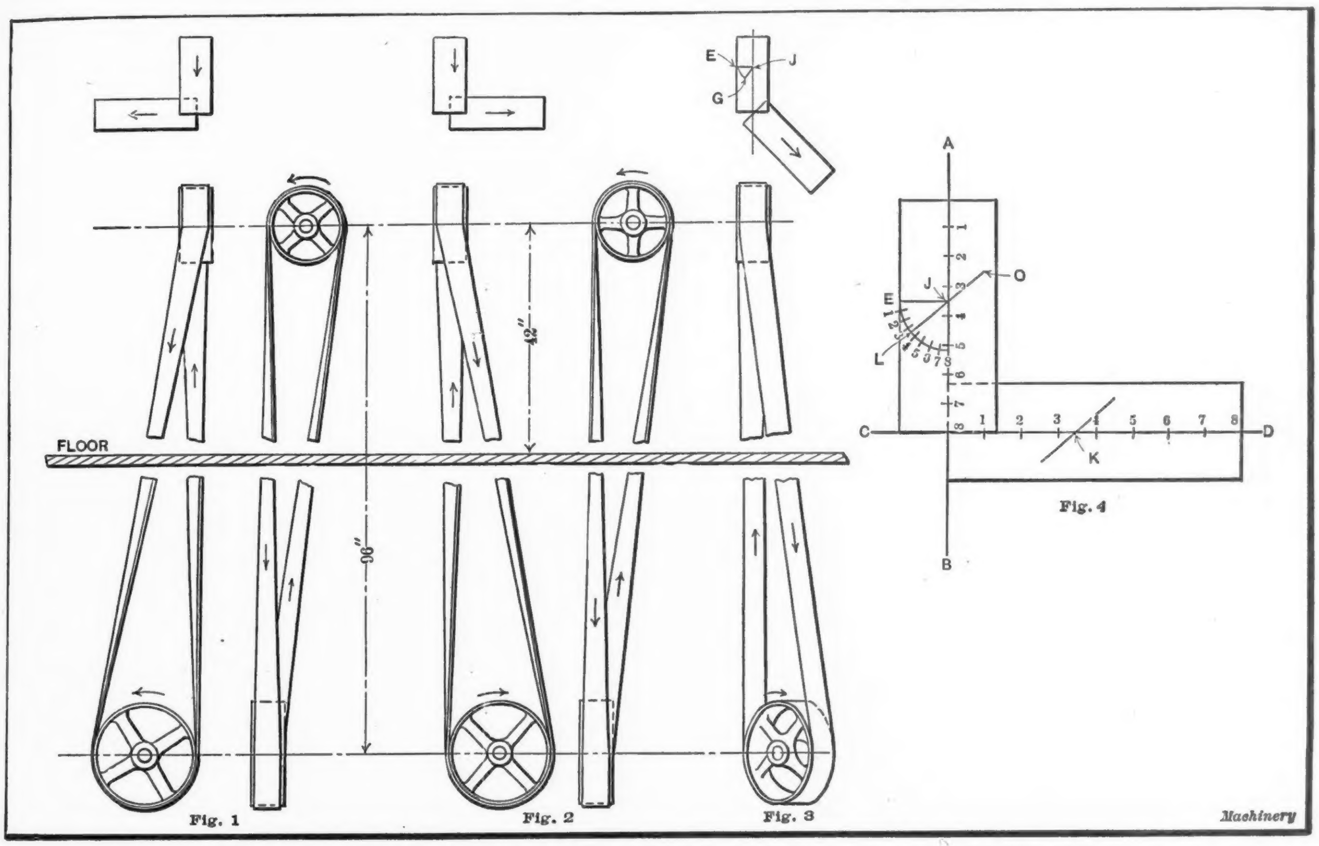
An article in the *Zeitschrift des Vereines Deutscher Ingenieure* records a number of tests made with belting. These tests indicate that the tension when the flesh side of the belt runs onto the pulley can be 12.5 pounds per inch of width greater than the tension when the belt is run with the hair side in contact. The limiting speed with the hair side of the belt towards the pulley, is about 60 per cent of that with the flesh side towards the pulley.

ALIGNING PULLEYS FOR QUARTER-TURN BELT DRIVES

BY M. H. BALL*

The aligning of pulleys on shafts which are at an angle of 90 degrees to one another—or what are commonly known as quarter-turn drives—and the laying out of holes for the belts in an intervening floor, are problems which are met with so infrequently by the average machinist or millwright that the methods to be used are apt to be forgotten. Sometimes considerable time is, therefore, spent on this work, and a great deal of wasted effort might be saved if instructions given in a simple way were available. The object of this article is to show how work of this kind can most easily be done.

The rule for the alignment of the pulleys is as follows: The center of the face of one of the pulleys at a point level with the center of its shaft, must be in the same vertical line as the same point on the other pulley. The exact condition required is indicated in the plan views of the accompanying illustration. The direction in which the pulleys are to turn determines which of their sides must be in line, as it is always the sides from which the belt leaves the pulleys which should line up. Fig. 1 shows how the pulleys should be set when the lower pulley turns to the left, as indicated by the arrow. Fig. 2 shows the setting when the lower pulley is driven in the opposite direction. The rules given apply to the aligning of pulleys at other angles as well, an example of which is shown in Fig. 3.



Figs. 1 to 4. Method of Aligning Pulleys and Laying-out Holes for the Belt in an Intervening Floor

The second problem met with in many cases of this kind is the laying out of holes in the floor for the belt. Fig. 4 shows a method of laying out the floor holes for the drive indicated in Fig. 2. First draw an outline (plan view) of the two pulleys on the floor in full size, directly below and above the respective pulleys to be connected by the belt. A starting point for this layout can readily be found with a plumb bob. Then draw the center lines *AB* and *CD* through the faces of the pulleys, and divide the diameter of each pulley into eight parts, as shown, numbering the divisions 1, 2, 3, etc. The numbers of the divisions must start from the sides of the pulleys which are opposite the arrow points shown in the plan view indicating the direction of rotation. Next, measure the distances from center to center of the shafts and from the center of the

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upper shaft to the floor. In the example shown the distance from center to center of the shafts is 96 inches, and the distance from the center of the upper shaft to the floor is 42 inches. As $96 \div 8 = 12$, each division on the diameter of the pulleys is equivalent to 12 inches. Further, $42 \div 12 = 3\frac{1}{2}$, which represents the number of spaces that the center of the belt will be from the center points of the sides of the upper pulley, as indicated at *J* and *K* in the engraving. Draw the line *EJ* through the point thus located in the rectangle representing the upper pulley. Then strike an arc with *J* as center and *EJ* as radius, as indicated, and divide it into eight equal parts. As we are working on the top side of the floor, and as our measurements from the floor to the upper shaft determine how many spaces we are to set off, start numbering these divisions from the point *E*, the line *EJ* being parallel to the face of the upper pulley; then set of $3\frac{1}{2}$ spaces from *E*, thus determining point *L*, and draw line *LO* through *J*, making *JO* equal to *LJ*. This line indicates the position of the center of the belt at the floor line and a line of the same length parallel to it through *K* indicates the other center line of the belt at the floor line.

The lay-out for an angle of other than 90 degrees, as indicated in Fig. 3, differs only in that the arc on the pulley outline extends only from the line *EJ* to the line *GJ*, Fig. 3, this latter line being parallel to the face of the lower pulley. Any number of divisions, either more or less than eight, may be used in the lay-out if it would be more convenient.

* * *

INCREASING BOILER CAPACITY BY MECHANICAL DRAFT

The United States Bureau of Mines makes the statement in Bulletin 18," The Transmission of Heat into Steam Boilers," just issued by the Bureau of Mines, Washington, D. C., that the present steaming capacities of steam boilers can be tripled or quadrupled by forcing over the heating surfaces three or four times the weight of gases now passed over them, as follows: "With well-designed mechanical-draft apparatus this greater weight of gases can be forced through the boilers at small operating cost. It is possible to increase the capacity of many of the present boilers in this way without reducing their efficiency much; in fact by proper arrangement of the heating surfaces the efficiency can be made higher than the present rating. The efficiency of any boiler can be increased by arranging its heating surfaces in series with respect to the path of hot gases. New boilers of high efficiency can be constructed by making the cross section of the gas passages small in comparison with the length.

"Nearly a hundred years of practical investigation of boiler and furnace problems has resulted in little advance. Perhaps the main reason why many of the investigations failed to bring about progress was that boiler and furnace were considered a unit and were investigated together. Various combinations of boilers and furnaces have been built and tested without thoughtful planning. Many of the published results of such tests confuse the performance of the boiler and the furnace in such a way that it is difficult, if not impossible, to tell which of the two should be blamed or praised for the poor or good results obtained from the combined apparatus. Evidently many persons have thought that the combined efficiency could be greatly increased by some mysterious manipulation.

"The principles governing the combustion of fuel in boiler furnaces and the absorption of heat by boilers have been little understood. The dogmas that the area of grate should have a certain ratio to the area of the heating surface, and that it takes ten square feet of heating surface to make one boiler horsepower, seemingly had become so thoroughly fixed in the mind that they were hardly ever questioned. It is only within the last decade that a few engineers have broken away from the old rule-of-thumb methods and have begun to investigate the functions of the boiler and furnace separately. Their studies seem to mark the beginning of advance in steam-generating apparatus.

"The boiler is the metallic vessel that contains water and steam and absorbs heat; consequently it should be studied as a heat absorber. The furnace is that part of the steam-generating apparatus in which the potential energy of the coal is changed into heat; consequently it should be studied as a heat generator."

* * *

Whenever possible put the supporting ribs in castings directly under the load, and not at the sides of the load, as is often done.

TRUCK FOR MOVING HEAVY MACHINE TOOLS

The truck shown in Fig. 1 was designed to meet the requirements in the warehouse of the Fosdick Machine Tool Co., Cincinnati, Ohio, where there was no crane and it was necessary at times to move the completed machines about. As the illustration clearly shows, this truck is of simple construction and has three wheels. These wheels are furnished with Hyatt roller bearings, and it is possible for one man to put

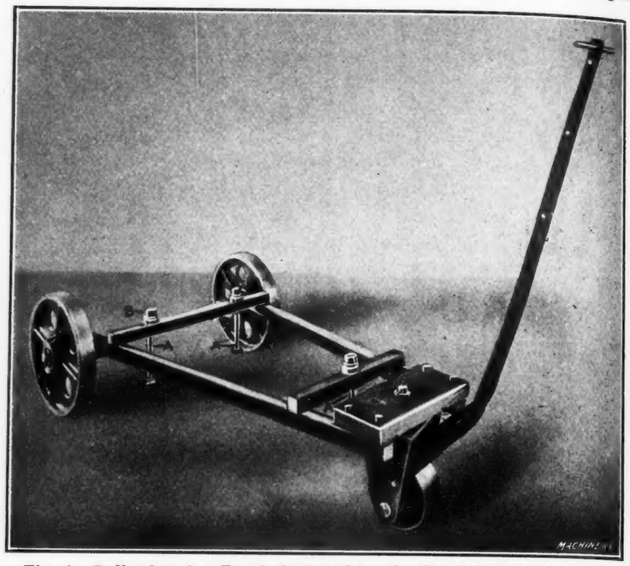

Fig. 1. Roller-bearing Truck designed by the Fosdick Machine Tool Co. for handling Heavy Machine Tools

a machine on the truck, pull it into the warehouse, and place it wherever desired. The machine is held to the truck by three bolts *A*, which are provided with ball bearing thrust washers *B* under the nuts.

The manner in which a machine is lifted and carried by this truck is shown in Fig. 2, where a 3-foot radial drill weighing 3600 pounds is shown ready to be moved about.

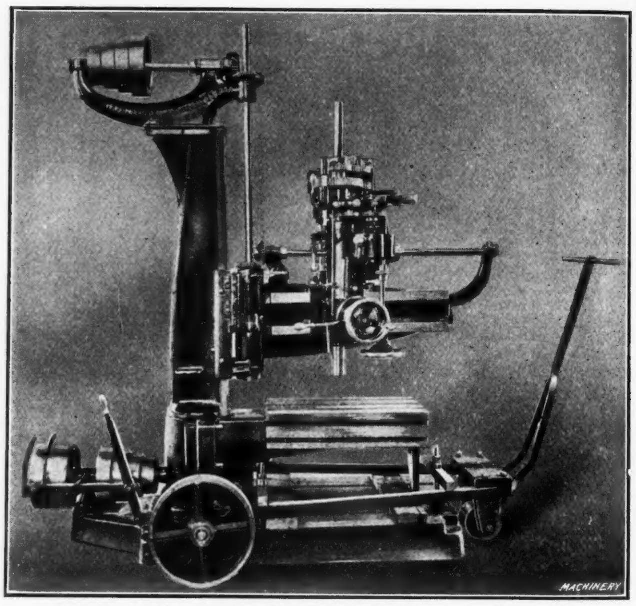

Fig. 2. A Three-foot Radial Drill raised from the Floor and ready to be moved

The bolts *A* going through the cross bars are inserted in the T-slots of the base of the machine, and by turning the nuts with a ratchet wrench, the machine is easily raised from the floor. The entire weight of the machine is taken on the truck, which, as before mentioned, has roller bearings in the truck wheels, thus enabling it to be moved about easily. The ball bearing thrust washers under the nuts on bolts *A* facilitate the raising of the machine. These trucks have been built in several sizes, the largest being designed to carry a 4-foot radial drill, which weighs approximately 6000 pounds.

* * *

Keeping a machine in good order is one thing and eternally tinkering with it is quite another.

WATCH MOVEMENT MANUFACTURE*—3

METHODS, MACHINES AND SPECIAL TOOLS USED BY THE SOUTH BEND WATCH CO.

BY DOUGLAS T. HAMILTON†

To produce the small parts of a watch such as staffs, pinions, screws and jewel settings, requires the use of specially designed machinery. It is the methods employed in the producing of these parts, and the care taken in their manufacture, that raises or lowers the value of a watch. Automatic machinery has been a great boon to watch manufacture, but if all parts thus made are not carefully inspected and assembled, there is very little gained by producing them automatically. All parts that enter into a South Bend watch, whether made on automatic machines or otherwise, pass through careful inspections, and all are assembled by expert watchmakers. In the following a few of the special machines used will be described.

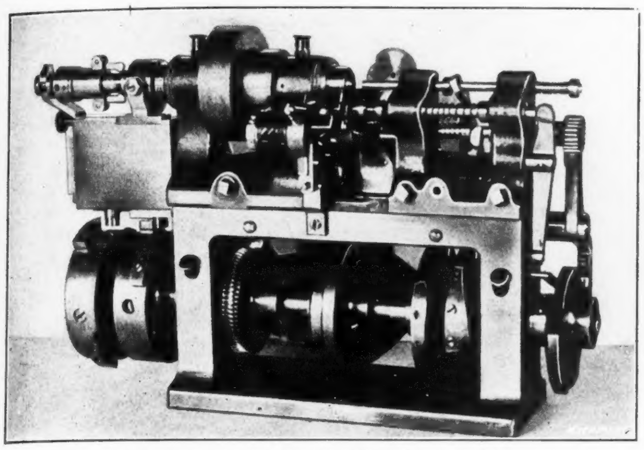

Fig. 26. Automatic Pinning Machine for Bridges

Pinning or Doweling Bridges

The most expensive watches consist of one front plate and several bridges, these forming the bulwarks for the movement. The bridges are pinned and screwed to the front plate and retain the jewels which act as bearings for one end of the staffs. The more important operations on the bridges are: Blanking and shaving in the punch press, facing, stoning, drilling in a jig, counterboring, recessing and pinning or doweling.

The pinning is accomplished in the automatic machine shown in Fig. 26, which is similar, in appearance, to a small automatic screw machine. The construction of this machine is more clearly shown in Fig. 28. The wire from which the pins are made is fed by a feeding tube *A* by means of a finger which is operated by cam blocks on wheel *B*. The chuck *C* is closed by fingers *D*, operated by a sleeve *E* and cam blocks on wheel *F*.

The wire is gaged to the desired length by a spring actuated stop *G* which is forced forward against the tension of the coil spring *H* by means of yoked lever *I* and cam *J*. The circular cut-off tool *K*, working at an angle of 45 degrees with the axis of the spindle, is then brought in through the medium of a rack and gear, by lever *L* and cam *M*. Before the pin is cut off, stop *G* drops back, and carrier *N* held on shaft *O* is operated or rotated into position by cam *P*, rack-lever *Q*, and pinion *R*. When in line with the work, the carrier is forced forward by cam *S* and lever *T*, thus gripping the pin and then dropping back.

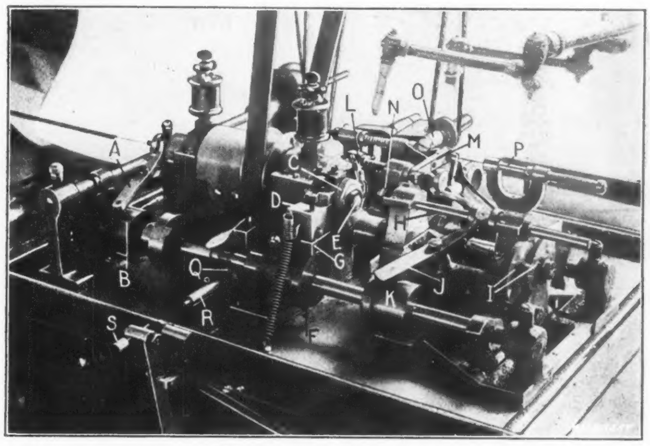

Fig. 27. Automatic Machine for Producing Small Watch Screws

The bridge in which the dowel or pin is to be inserted is held in a cage into which it is placed by the operator. Now as the carrier drops back, cam *P*, rack-lever *Q* and pinion *R* rotate the carrier into a position where the pin is in line with the hole in the bridge; then carrier *N* which is provided with a spring plunger *V* ejects the pin, inserting it in the work when acted upon by plunger A_1, lever B_1 and cam C_1. The main drive shaft, carrying the various operating cams, is driven by a pulley D_1 through a worm E_1 and worm-wheel F_1. The various cams are so timed that while the pin is being inserted in the work, another pin is being fed out and cut off, these operations being performed automatically.

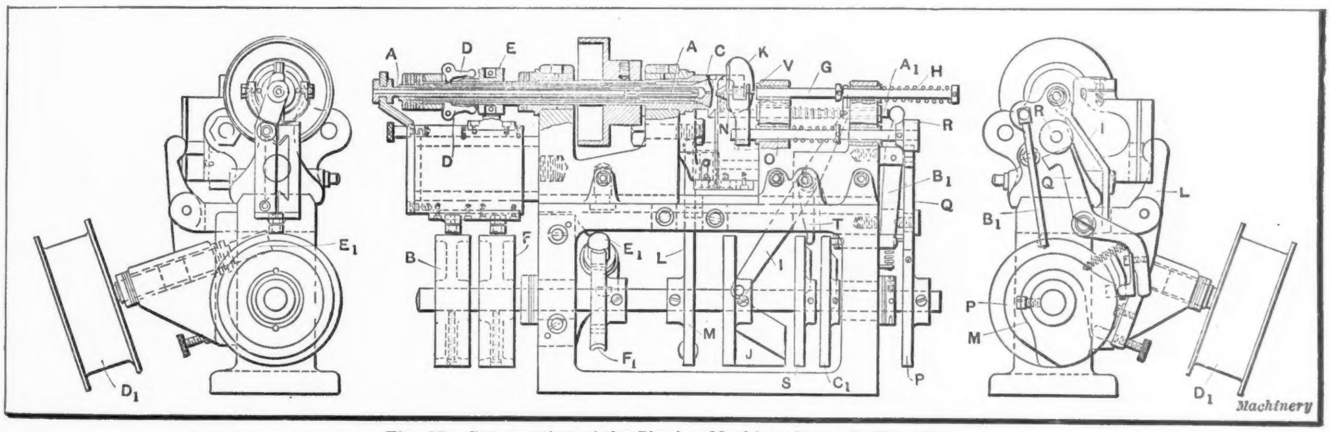

Fig. 28. Construction of the Pinning Machine shown in Fig. 26

Small Automatic Screw Machine

A large number of the cylindrical parts which are used in a watch are produced on the Brown & Sharpe automatic screw machine, but most of the small screws are made on special screw machines, one of which is shown in Fig. 27. The stock—the exact size of the head of the screw—is fed through the spindle by a feed finger operated by lever *A* and cam *B*.

The body of the screw, or portion to be threaded, is reduced by a circular form tool *C* held to a block *D*, as shown. This block is fulcrumed at *E*, and is operated by a cam *F* pressing against the hardened shoe *G*. It will thus be seen that the cutting edge of the tool, when in operation on the work, passes through an arc. This method of presenting the tool to the work has been found to give better results on

* The second installment of this article was published in the June number of MACHINERY. The fourth and last installment will occur in an early issue.

† Associate Editor of MACHINERY.

small work than feeding the tool in a horizontal plane, as is the usual practice.

The thread is cut by a small mill- or spring-die held in the forward end of spindle *H*. This spindle is rotated from the rear driving shaft through the change gears *I*, and is advanced by yoked lever *J* and cam *K*. The cams *F* and *K*

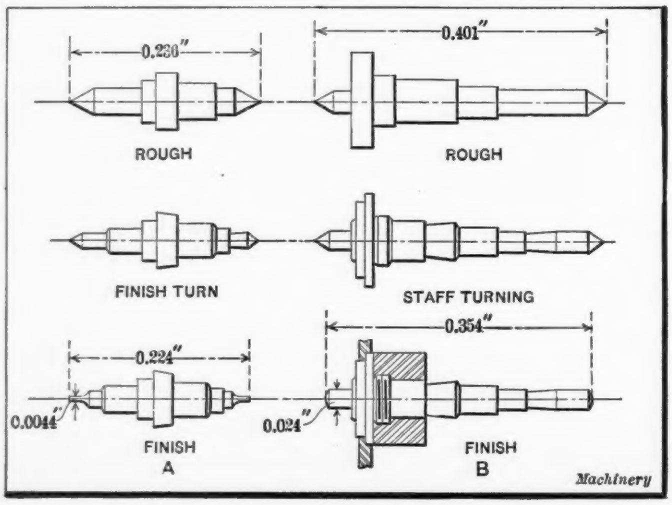

Fig. 29. Various Turning Operations on the Center and Balance Staffs

are so timed that the form tool is raised out of the way to let the die reach the work, the shoe *G* dropping down onto the cut-away portion of *F* at the proper moment. The die in traveling onto the work rotates in the same direction as the spindle, the latter reversing to run the die off when the desired length of thread has been cut.

After the thread is completed, the cut-off blade *L* operated by a cam on the rear shaft comes into action, and severs the screw from the bar. Just as the screw is breaking off, a bushing held in arm *M* is rotated into position to grip the screw, by

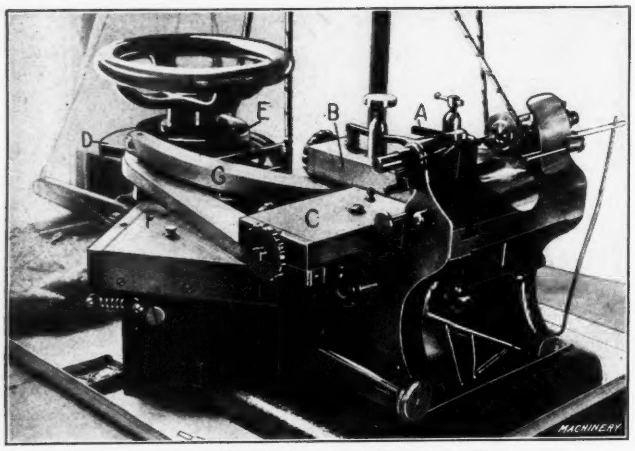

Fig. 30. Multiple Shoulder Staff Turning Machine

means of a fan gear *N* and a friction pinion not shown. The arm then rotates back into position in front of the slitting saw *O*, which by means of a cam and the fulcrumed holder in which it is retained, travels down past the head of the screw and cuts the slot. Spring plunger *P* is now forced forward by a cam, and ejects the slotted screw from the bushing. This cycle of operations is repeated until the bar is used up, when the camshaft is stopped by means of a simple device. This consists of a worm and worm-wheel *Q* which feed out a shaft *R* until it comes in contact with an adjustable stopscrew *S*, thus operating a lever which disconnects the driving clutch.

Staff Turning

The wheels composing the watch train are held on staffs, the ends of the latter running in jewels retained in the lower plate and bridges. Most of these staffs are provided with a number of shoulders of different diameters, as shown in Fig. 29, where *A* represents the various operations on the balance staff, and *B* the operations on the center staff. The last operation on the center staff shows the center wheel and pinion assembled.

One of the machines used for multiple shoulder staff turning is shown in Fig. 30. The staff to be turned is held on female centers, and is driven by a small dog. The turning is accomplished by a single turning tool *A*, held to the tool-slide *B*, which, in turn, is connected to a longitudinal slide *C*. Only one-half of the staff is finished at each setting, it being reversed to finish the other end. The movements of the turning tool *A* are controlled automatically by plate cams *D* and *E*. The lower cam *D* traverses the slide *C*, and hence moves the turning tool across the work by means of lever *F*, the ratio of the arms of which is 4 to 1. The top cam *E*, operating lever *G*, controls the in-and-out movements of the turning tool, and thus governs the diameter of the staff. The arms on lever *G* have a ratio of 8 to 1, thus enabling greater accuracy to be obtained on the diameter of the staff. The heights of the lobes on the cams, of course, are made equal to the movements required, multiplied by the ratios of the arms of the levers.

The lobes on cams *D* and *E* are so laid out and timed that all shoulders on the staff are faced as well as turned to a given diameter. One girl operates two machines, re-

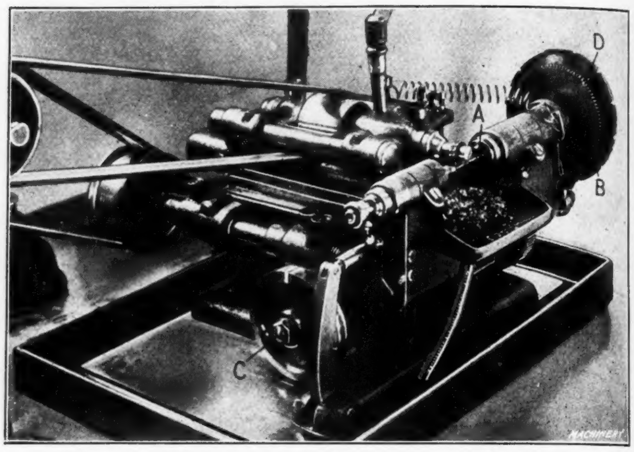

Fig. 31. Automatic Three-cutter Pinion-cutting Machine

moving a staff when finished and inserting a rough one. The machine is stopped automatically by a tripping device, not shown. The operator sits on a chair which is provided with wheels running on a track. This enables her to get from one machine to the other quickly and with very little effort.

Cutting Pinions

Watch pinions, as a rule, are made of steel and are formed-turned and cut off in special automatic staff machines. Then they are placed one at a time on an arbor, the latter being placed between the centers of the machine shown in Fig. 31. The driving center is corrugated, while the dead center is of the female type and is held in a spring-actuated

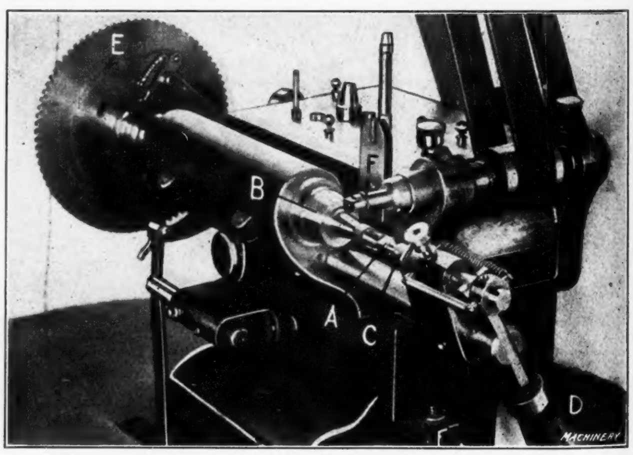

Fig. 32. Machine for cutting the Teeth in the Brass Wheels

spindle or tailstock. As a rule, three cutters are used: The first is a thin saw; the second a roughing cutter; and the third a finishing cutter.

The spindle *A* carrying the corrugated center is indexed by means of an indexing disk *B* and a ratchet. After the work has made one complete revolution, a cam held on cam-

shaft C shifts the table, bringing the next cutter into operation. The spindle again makes one complete revolution, when the cam shifts the table, bringing the last or finishing cutter into line. This makes one cut around the pinion, after which the table drops back to the starting position, and the machine is stopped by an automatic tripping device. The index plate D is provided with the same number of notches as there are teeth on the pinion.

Cutting Brass Wheels

The brass wheels, which in connection with the pinions compose the watch train, are blanked out and shaved by sub-

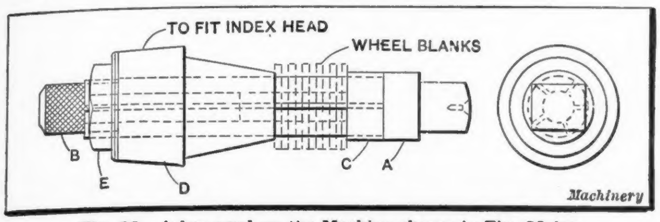

Fig. 33. Arbor used on the Machine shown in Fig. 32 for Holding Brass Wheels

press dies in the punch press. The arms of these wheels are all equally spaced and made of an equal width. The automatic machine used in cutting these wheels is shown in Fig. 32. Eleven of the wheels are held on the arbor A which has a tapered shank fitting in the indexing spindle B. The forward end of the arbor is supported by a spring center C, which is withdrawn from the arbor by pressing on the handle D. The indexing disk E has the same number of teeth as that required in the wheel and is indexed automatically by a ratchet device.

The cutter F is held on an arbor placed in the spindle of the machine. The head carrying the cutter spindle is raised on the return stroke of the cutter by a cam located beneath the head. The table carrying the work is advanced at a uniform speed by a constant-rise cam held on a cam-shaft at the rear, and an automatic arrangement stops the machine when one stack of wheels has been completed.

The arbor on which these wheels are held while the teeth are being cut is shown in Fig. 33. It consists of a central arbor

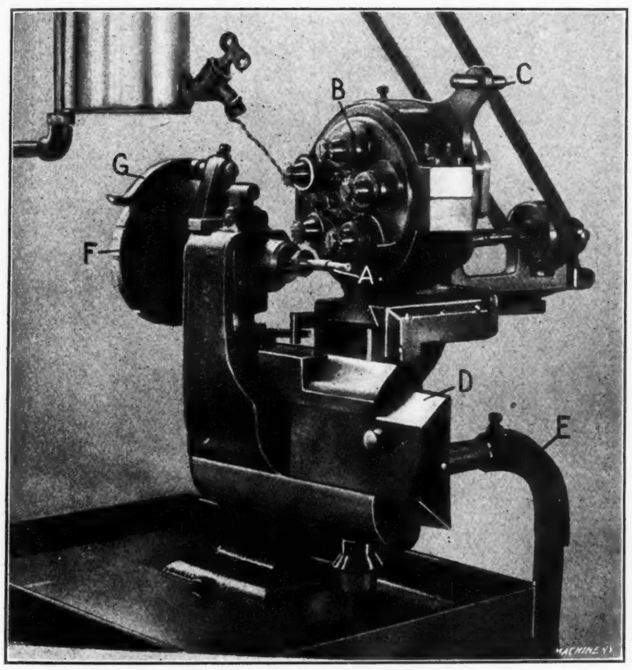

Fig. 34. Machine for Cutting Brass Escape Wheel Teeth

A which has five slots cut in it of the same width as the arms of the wheel. A hole is bored part way through this arbor, and a plug B is inserted to prevent it from collapsing. A washer C of the same diameter as the shoulder on the arbor is put on it as shown; then the wheels are put in place and the tapered sleeve D, which fits the index head, is next slipped over the arbor. Collar-nut E is then screwed onto the threaded end of the arbor, thus clamping washer, wheels and sleeve together.

As these wheels are blanked out and shaved in the punch press, it is evident that the inside of the rim is practically the only place to work from, if a wheel having a rim of an equal width throughout its circumference is desired. By working from this point, and using a milling cutter which will finish the tops of the teeth, it is an easy matter to produce a wheel which will be perfectly balanced.

Cutting Brass Escape Wheels

The escape wheel, so called because of the function it performs in a watch, is made from either steel or brass. The brass wheels are cut by sapphires, seven of which are used as fly-cutters, while the teeth in the steel wheels are produced by hardened steel cutters. Each of these cutters forms one part of the tooth, which differs considerably in shape from an ordinary gear tooth, as can be seen by referring to Fig. 8 in the May number.

The machine used for cutting the teeth in brass escape wheels is shown in Fig. 34. A stack of these wheels is held on arbor A, the latter being retained in the indexing spindle. The teeth are completely formed by five cutters held in the revolving head B, each cutter shaping some part of the tooth. The cutter spindles are driven by gears enclosed in the head. The cutter head itself is indexed by hand to bring the de-

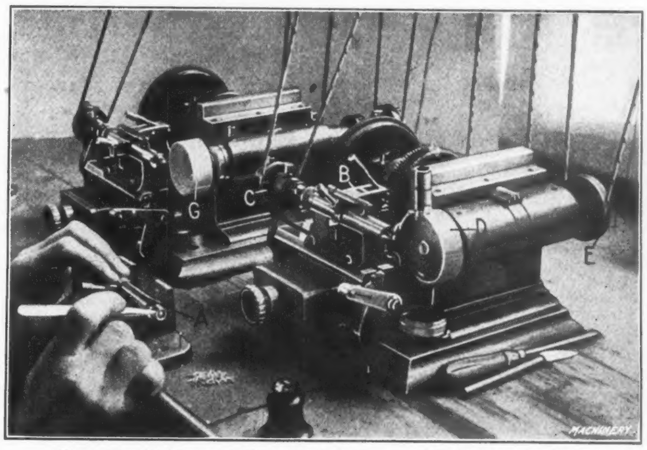

Fig. 35. McGinty Staff Cone Grinding and Polishing Machine

sired cutter into operation, this indexing being effected by means of the handle C. The table or slide D is traversed by hand by means of the lever E. The work is also indexed by hand with the ratchet wheel F, the latter being held in the desired position by pawl G. The teeth in these escape wheels are so delicate that it would be practically impossible to produce them by means of an automatic machine, great care being required on the part of the operator to turn out a perfect wheel.

As it is impossible here to give even a short description of the making of all the parts of a watch movement, only those methods which involve the use of some interesting mechanical device or appliance have been selected. After the steel parts such as pinions, staffs, balance staffs, etc., have been made, they are hardened and tempered. This leaves them in such a state that it is necessary to lap and polish them to the desired size, at the same time improving their appearance.

Grinding and Polishing Machine for Staff Cones

The staffs on which the wheels are held have a coned bearing, which must be of exact size to fit the hole in the balance wheel jewels inserted in the wheel. The staff to be ground is placed in a quill A, the operator using a pair of tweezers for this purpose, as shown in Fig. 35. The quill is then placed, and held by clamp B, in that part of the machine shown to the right in the illustration, which is used for the first operation—grinding. The spindle of the quill A is driven by a grooved pulley C and a small dog, the latter coming against a lug on the quill spindle. The staff is held between pump centers and a faceplate, and the grinding is accomplished by a diamond charged lap D, which is rotated by pulley E.

The spindle carrying the lap is moved back and forth by a cam which, in turn, is operated by a worm and worm-

wheel. This cam is provided with a gradual rise for feeding the lap against the work. When the desired diameter is reached the machine is stopped by means of a trip-stop.

The machine shown to the left is used for polishing the cone on the staff, and is identical in construction with that just described, with the one exception that the lap is given an oscillating movement by means of a crank *F*, shown in Fig. 37. This latter illustration also shows more clearly the construction of this machine. The lap is made of celluloid and

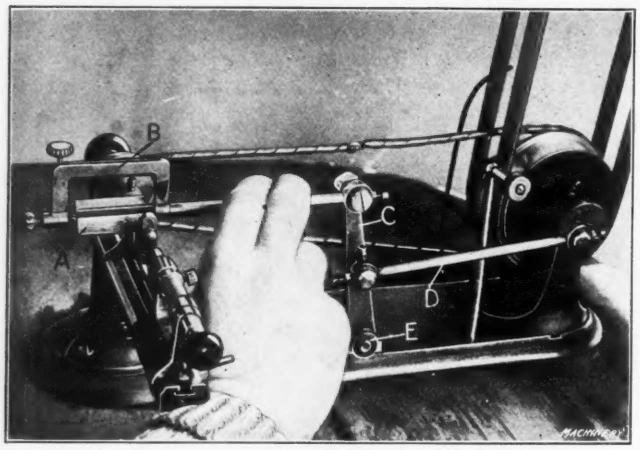

Fig. 36. "Wig-wag" Polishing Machine for Pinions and Staffs

is coated with Vienna lime, obtained in Austria. It is kept in contact with the work by means of a cam that has a cut-away portion, allowing the lap to drop back when the cone has been lapped to the correct diameter.

Before this machine—nicknamed the McGinty cone polish-

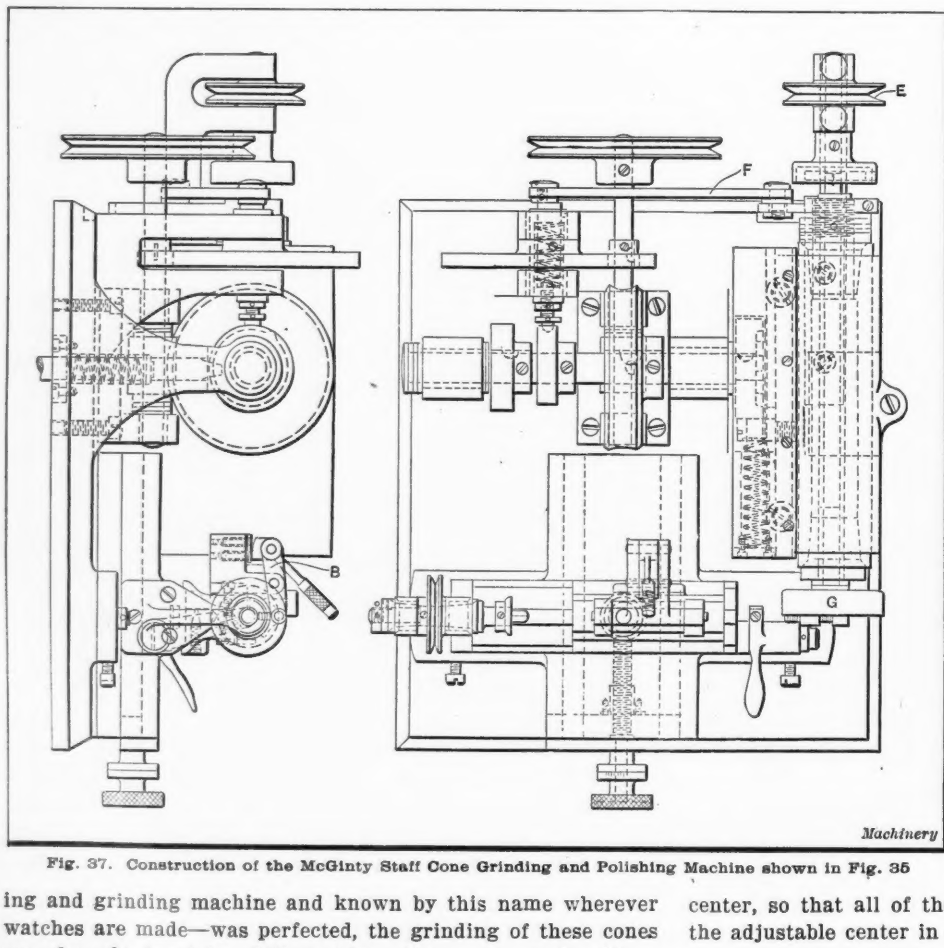

Fig. 37. Construction of the McGinty Staff Cone Grinding and Polishing Machine shown in Fig. 35

ing and grinding machine and known by this name wherever watches are made—was perfected, the grinding of these cones was done by hand by skilled staff makers, who made this a special business. Naturally, when this machine was invented, it was jeered at by these expert cone polishers. About this time the old song "Down went McGinty" was at the height of its popularity, and each time this machine returned to the tool-room for improvements, the polishers would strike up the old refrain. However, after much experimenting the machine was perfected, and at the same time was nicknamed "The McGinty cone and polishing machine." It is now operated by girls who do better work and more of it than was formerly accomplished by expert polishers.

Polishing Pinions and Staffs

The pivot ends of pinions and staffs are polished by means of "wig-wag" polishers, one of which is shown in Fig. 36. The pinion is held in a "balloon" chuck provided with a pump center, and the polishing is done with a wing polisher *A* made of machine steel. The wings are ground on a special fixture, to an included angle of 45 degrees, and these lapping

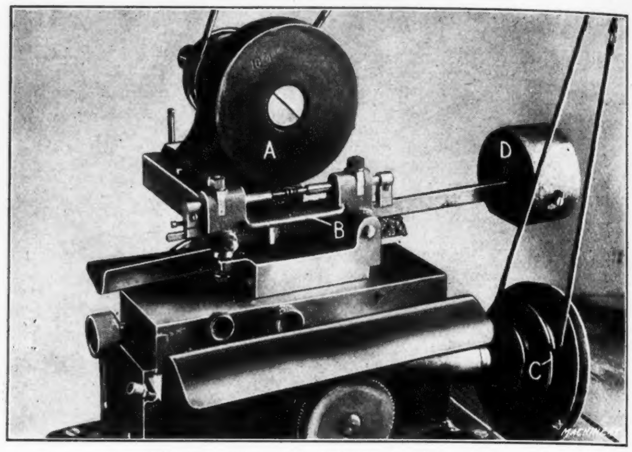

Fig. 38. Pinion Leaf Polishing Machine

edges are charged with rouge mixed with pure lard oil. The wing polisher is held in a bracket *B* which is fastened to a bell-crank *C*, the latter being operated by a connecting-rod fastened on the end of the driving shaft.

In operation, after the part to be polished is placed in the chuck, the frame holding the wing polisher is brought down and the latter kept in contact with the work, as shown in the illustration. As bell-crank *C* is fulcrumed at *E*, the action of the eccentric transmits an oscillating movement to the wing polisher. The machine is furnished with an idler pulley, so that it can be stopped by operating a foot lever, when inserting the work in the chuck.

Polishing and Grinding Pinion Leaves

As previously stated, all steel parts are hardened and tempered, and the pinions are no exception to this rule. After hardening, the leaves or teeth of the pinions are lapped in the machine shown in Fig. 38. The pinion is held between centers, which are retained in a stationary slide *B*. A circular lap *A* made of fiber, and provided with annular grooves, is charged with emery and driven at a high rate of speed. This lap is fed across the work by a cam in one direction and is returned by a coil spring. The cam is operated by a worm and worm-wheel driven from the grooved pulleys *C*.

Traversing the lap across the work rotates the latter on the center, so that all of the leaves are lapped. Weight *D* keeps the adjustable center in contact with the work.

Grinding the Teeth of Steel Escape Wheels

Steel escape wheels are hardened and tempered, which, of course, distorts their teeth, making it necessary to grind them. This operation is accomplished in the machine shown in Fig. 39. The escape pinion is held on an arbor *A* and is brought in contact with the fine laps shown at *B*, three of which are located at different angles to each other. When grinding, the operator grips the yoke *C* with one hand, swing-

ing it around so that different portions of the escape tooth are brought in contact with the faces of the various grinding wheels. When one tooth is completed (it is ground in three different places) the arbor carrying the escape wheel is

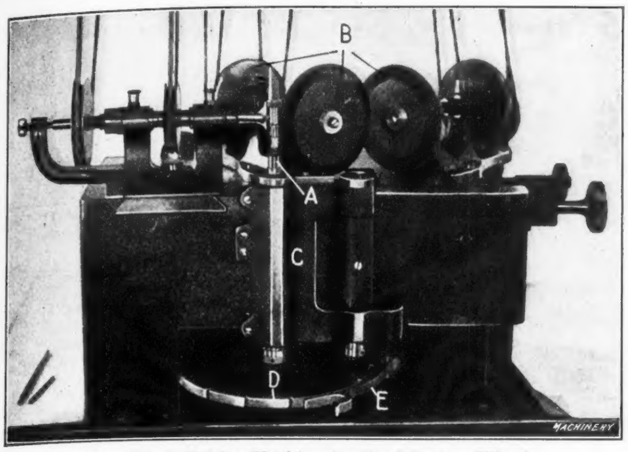

Fig. 39. Polishing Machine for Steel Escape Wheels

indexed by means of dial *D* and pawl *E*. This cycle of operations is repeated until the escape wheel is completed, 45 grinding operations being necessary for each escape wheel.

* * *

GRADUATING MACHINE OF NOVEL CONSTRUCTION

A graduating machine without a pawl and ratchet for indexing the work is shown in Fig. 1. The manner in which the indexing of the work is accomplished is rather unique, and is also very accurate, as there is a positive movement for each indexing, and no chance for a pawl to slip or get out of order. This device is of a very simple construction and is much smaller than the average graduating machine employed on the same class of work.

The graduating device consists essentially of a worm and worm-wheel for rotating the work, and a five-lobed cam, driven by two spur gears having a ratio of 5 to 1, for imparting the necessary movement to the graduating tool. The work *A*, Fig. 1, which in this instance is the base for the slotting at-

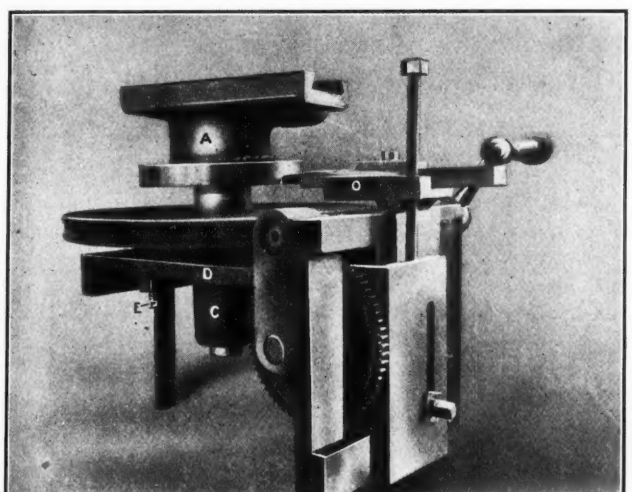

Fig. 1. A Graduating Device in which the usual Indexing Ratchet and Pawl is dispensed with

tachment used on the Rockford milling machines, is held on a spindle by a washer and nut, the spindle being located in a holder *C* provided with a boss resting on table *D*, and adjustable in a slot cut in the latter. This holder is held in the desired position by two set-screws and a cross bar *E* fitting in a notch in the holder and located under the table.

The worm-wheel *F*, Fig. 2, on the boss of which the work rests, is fastened to the spindle and is rotated by a single, right-hand worm *G* (10 threads per inch) operated by the handle shown. This worm is held rigidly to shaft *I*, but gear *K* is held on a sliding key allowing the shaft to move laterally.

The five-lobed cam *J*, for imparting the required movement to the graduating tool, is rotated by spur gears *K* and *L*, which have a ratio of 1 to 5, so that for every complete revolution of the worm, cam *J* makes 1/5 of a revolution. One lobe on this cam is longer than the others, thus making every fifth line longer than the other four.

The graduating tool is held in a holder clamped to slide *O*, which latter fits in a dovetailed groove cut in the frame of the fixture. The adjustable block *P* for moving the graduating tool to the correct height, is fastened to slide *O* by a collar-head screw *Q* and is adjusted by screw *R*. This block is provided with a shoe projection *S*, which rests on the five-lobed cam, thus providing a means for raising and lowering slide *O*.

The indexing device is ingenious, consisting simply of a 10 threads per inch, single worm, one end of which is provided with a cam face having a throw of 0.100 inch per revolution. The boss of the bearing with which this cam is in contact is also provided with a cam face having an equal throw. A pin driven into this boss would serve the same purpose as the cam face, but would not give as smooth an action. Now, when the worm is rotated in a right-hand direction it travels to the left, as shown by the arrow in Fig. 2, owing to the action of its cam face, and in so doing does not transmit any movement to the worm-wheel.

This action may seem rather singular, but it is easily explained if we consider the worm-wheel as a stationary nut

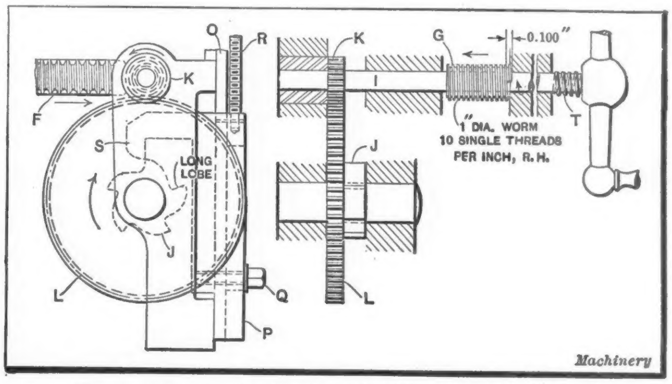

Fig. 2. Diagram showing the operation of the Indexing and Graduating Mechanisms

and the worm as a screw free to move laterally. In this case the worm-wheel is held stationary by friction and the weight of the work, while the worm is forced to the left due to the action of its cam face. As there is sufficient clearance between the two bearings, it will be seen that the worm, when being rotated, is free to travel, carrying the shaft *I* along with it in the direction of the arrow. When the end of the rise on the cam is reached, however, the worm, actuated by spring *T*, suddenly slides to the right a distance of 0.100 inch and carries the worm-wheel around through a space of one tooth.

The five-lobed cam is so timed with the cam on the worm that when the worm-wheel remains stationary, the graduating tool is producing the line. Then, as the graduating tool drops away from the work, the worm is suddenly pulled to the right by the action of the spring, indexing the work for the next graduation.

The worm-wheel shown in the illustration has 360 teeth and is used for graduating in degrees. Two other worm-wheels are used in connection with this device, one provided with 125 teeth and the other with 100 teeth. The worm-wheel having 125 teeth is used for graduating dials to read in thousandths of an inch, which are used on screws with 8 and 4 threads per inch, while the worm-wheel having 100 teeth is used for dials placed on screws with 10 or 5 threads per inch.

While some of the constructional features of this graduating machine could be improved on, the principle of indexing is unique and will no doubt be appreciated. It was designed and built in the shop of the Rockford Milling Machine Co., Rockford, Ill., where it has given entire satisfaction.

D. T. H.

THE MAKING OF BUSHINGS FOR DRILL JIGS*

PROPORTIONS OF BUSHINGS, MATERIALS USED, TURNING, HARDENING, GRINDING AND LAPPING OPERATIONS

BY F. B. JACOBS†

The making of a set of ten or twenty jig bushings is often looked upon as a long and tiresome operation with something of a degree of uncertainty as to results. This is especially true in some of the smaller shops as very few manufacturing concerns outside of the larger ones have anything like an effective system as applied to this class of work. It is not the intention of the writer to describe anything new but simply to outline the method employed in many of the medium sized shops in the Eastern states for getting out accurate jig bushings with a minimum amount of expense and trouble.

After the jig is bored the holes should be stamped 1, 2, 3, etc., and a chart drawn up as shown in Fig. 1. This need not be an elaborate affair as an ordinary pencil sketch will answer all practical purposes. The value of this chart is ap-

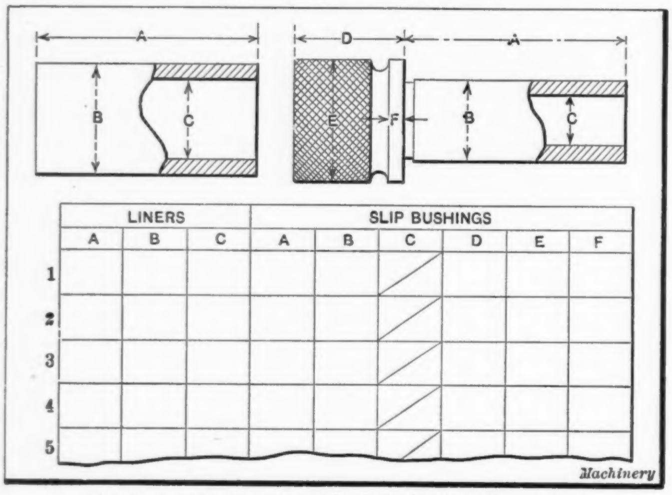

Fig. 1. Arrangement of Table of Jig Bushing Dimensions

parent, as the toolmaker can at a glance find any dimension for a bushing, thus saving much time that is generally spent in taking repeated measurements. For convenience the bushings are divided into three classes: Liners, shoulder bushings and slip bushings. If there are any solid bushings without shoulders that are used without slip bushings they can be listed with the liners. The letters A, B, C, etc. correpond to the dimensions of the bushings which are filled out in the chart in the spaces reserved for them. Two spaces are reserved under the column C for drill and reamer bush-

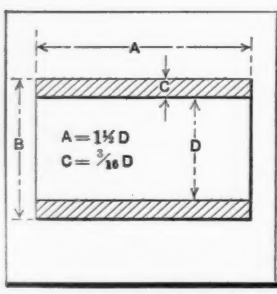

Fig. 2. Proportions of Lining Bushings

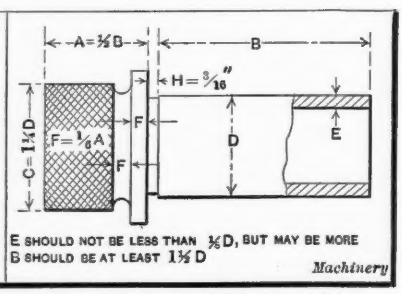

Fig. 3. General Proportions of Slip Bushings

ings that are to fit the same liner. The numbers 1, 2, 3, etc. correspond to the figures stamped on the jig to designate the different holes.

Very few manufacturers agree on a standard for the proportions of jig bushings, each preferring to follow their own ideas. In many cases they are left to the discretion of the toolmaker himself. The proportions shown in Figs. 2 and 3 will generally answer in the majority of cases. When it is necessary to make bushings of unusual length they are often relieved as shown in Fig. 4. Solid bushings should have a shoulder as shown in Fig. 5, when it is intended to have stop collars run against them.

In Fig. 7 are shown three methods of holding bushings to prevent their turning: *A* shows a bushing having a pin inserted which slips in a slot cut in the lining bushing; *B* shows a bushing having a slot milled through the collar, a pin being located in the jig to engage this slot; and *C* illustrates a more elaborate device that is sometimes used. The

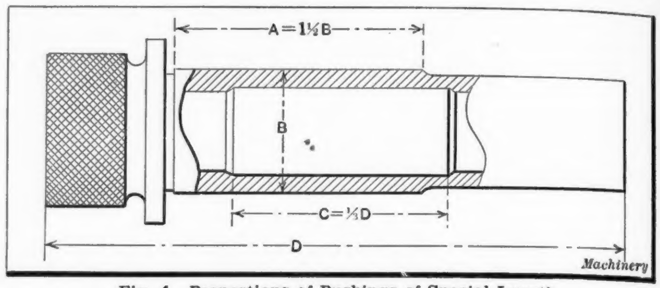

Fig. 4. Proportions of Bushings of Special Length

stop button which is fastened to the jig prevents the bushing from being drawn out of the liner while withdrawing drills or reamers, as well as preventing its turning.

Bushings are generally made of a good grade of tool steel which insures hardening at a fairly low heat thus avoiding to a great extent the danger of fire cracking. They can be made in much less time from ordinary machinery steel which will answer all practical purposes, provided they are properly casehardened to a depth of 1/16 inch. Where many bushings are to be made a large percentage of the cost of stock can be saved by using machinery steel.

There are several methods followed in turning jig bushings. Some toolmakers prefer to "chuck out" the hole to the desired

ALLOWANCES FOR GRINDING AND LAPPING BUSHINGS

Operation	Diameter of Bushings in Inches					
	½	1	1½	2	2½	3
A	0.008	0.010	0.013	0.016	0.020	0.025
B	0.0005	0.0005	0.0007	0.0008	0.0009	0.001
C	0.008	0.010	0.013	0.016	0.020	0.025
D	0.0003	0.0005	0.0007	0.0008	0.0009	0.001

A—Grind outside; B—Lap outside after grinding; C—Grind inside; D—Lap inside after grinding.

size and then finish the outside of the bushing by placing it on an arbor; others prefer to turn up the bushings two at a time, end to end, cut them apart and then bore as the final operation. This is an excellent method to follow when making large bushings. The most rapid method, however, is to chuck out the hole and finish up the outside at one setting using bar stock held in the chuck of a rigid engine lathe. This method is not always practicable on large bushings.

In making allowances for grinding and lapping, many toolmakers neglect to leave enough, which is the cause of many bushings having to be made over again on account of not finishing out. On the other hand many toolmakers leave too liberal an allowance for finishing thereby causing themselves a lot of unnecessary trouble and labor. The allowances given in the accompanying table can be safely used when the bushings are made somewhere near the proportions shown in Figs. 2 and 3, but for extra long bushings more liberal allowances should, of course, be made.

Before hardening the bushings should be plainly stamped with the size and purpose for which they are intended, "15/32 drill," "1/2 ream," etc. They should not be stamped with dull, worn out figures that are used by Tom, Dick and Harry on everything, but with a set of plain sharp figures reserved solely for this purpose. It is poor practice to try to stamp the words "drill," "ream," etc in a straight line,

* For additional matter on jig making and jig design see: "Locating Jig Buttons," June, 1912; "A New System for Locating Holes to be Bored on the Milling Machine," April, 1912; "Some Jig and Fixture Designs," January, 1911, and the articles there referred to. See also MACHINERY'S Reference Books Nos. 41 42 and 43, "Jigs and Fixtures."

† Address: 826 Arch St., Philadelphia, Pa.

as not one man out of a hundred can do this and turn out a respectable looking job. If, however, the words are laid out on a slight curve the results are more satisfactory as slight irregularities of alignment are not then so noticeable. Anyone can prove this to his own satisfaction by a little experiment with a steel alphabet and a block of cast iron. Sharp clean figures and letters neatly laid out not only im-

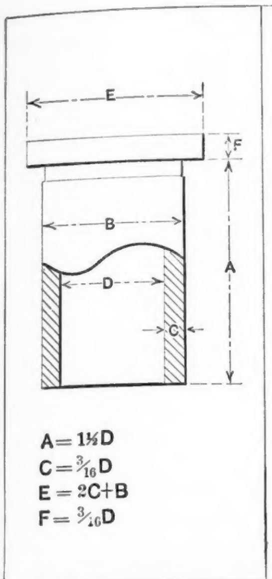

Fig. 5. Proportions of Shoulder Bushings

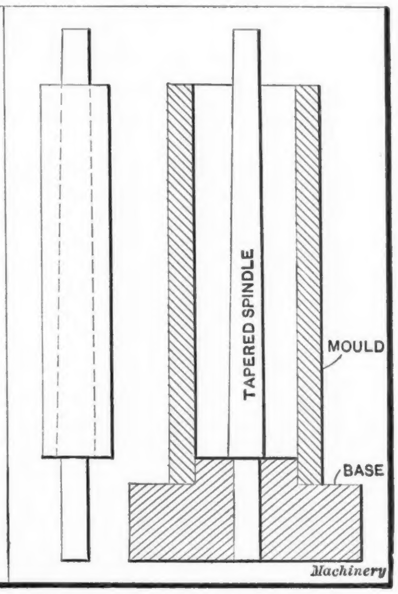

Fig. 6. Lead Lap and Mold used for Casting it

prove the appearance of the toolmaker's work, but also save the drilling operator a lot of time as sharp clean-cut figures can be read at a glance.

In hardening bushings made of tool steel they should be brought up to an even red heat in a clean fire, and the heating should never be hurried. If heated quickly the bushing is very likely to heat unevenly which invariably results in a warped piece that will not finish out. Gas furnaces are excellent for heating bushings preparatory to hardening. If, however, a gas furnace is not available a good clean charcoal fire in the forge will answer the purpose.

As soon as the bushing has been brought up to an even red heat it should be dipped in water warmed just enough to take off the chill. The bushing should then be brought up to

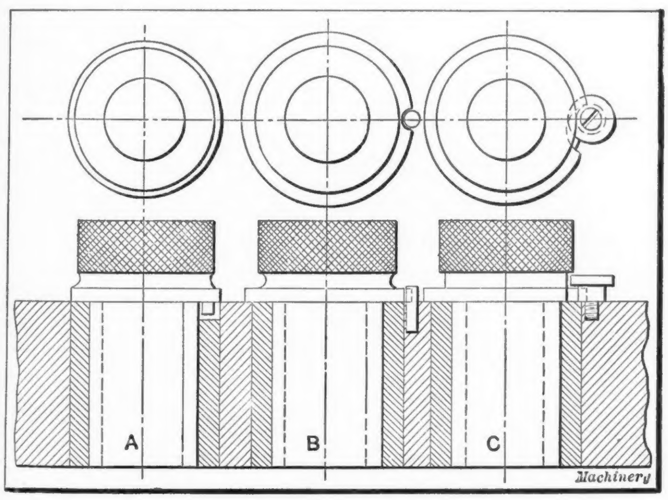

Fig. 7. Methods used for Preventing Jig Bushings from Turning

a "sizzling heat" and left to cool in the air. Some toolmakers draw bushings to a medium straw color. This is a mistake as it only tends to shorten their life.

Grinding and Lapping

There are four methods in common use for finishing holes in jig bushings, *viz:* Lapping with a lead lap, lapping with a lead lap followed by a cast-iron or copper lap, internal grinding, internal grinding followed by a cast-iron or copper lap for removing the last 0.0005 inch. The first method is dead wrong as it invariably results in bell-mouthed holes, especially when the toolmaker charges the lap while in use, which is very poor but at the same time very common practice. The second method is correct for holes too small to be ground conveniently. The third method is wrong as the grinding wheel, no matter how fine, leaves innumerable very fine scores and high spots. These high spots soon wear away leaving the hole oversize. The last method is correct and should be used whenever possible.

In Fig. 6 is shown a lead lap with a steel tapered spindle, and a convenient mold for casting the laps. This mold is provided with a base having a hole to receive the spindle that the lap is cast on. A number of laps can be cast in this mold at one heating of the metal and afterward turned to the size required. Fig. 8 represents a familiar form of cast-iron lap. This lap is split in three places, and provided with a taper-end screw for expanding it to compensate for wear.

Laps should always be charged before—not while they are in use. A good way to charge a lap is to lay it on a cast-iron plate on which some of the abrasive material has been sprinkled. A cast-iron plate small enough to be conveniently handled is then held on the lap and moved back and forth with a regular motion. The lap being rolled between two surfaces picks up a certain amount of the abrasive material. A lead lap can be charged in this manner very rapidly, as the grains of abrasive material readily imbed themselves in the soft metal. A cast-iron lap, being of a harder material, requires more time to properly charge.

Until the last few years emery was the abrasive generally used for lapping. At the present time, however, aloxite, a product of the electric furnace, is displacing emery as it cuts faster, producing excellent results in a comparatively short time as compared to emery. Nos. 90 to 150 are used in connection with lead laps for roughing operations. For the final finishing with cast-iron laps flour aloxite is used. When

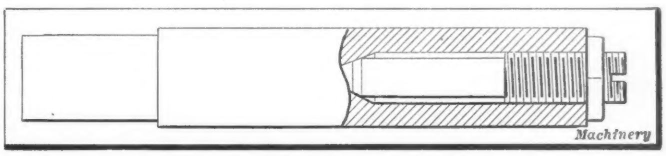

Fig. 8. Usual Form of Cast-iron Lap

not in use any abrasive used for lapping should be kept in a covered box to protect it from dirt and other foreign substances. A small chip or piece of grit will often cut a deep score in a piece of work—which neither improves its finish or workmanlike appearance.

Laps should always be run at a fairly low speed. Fifteen to twenty feet surface speed for a lead lap used for roughing, and twenty to twenty-five feet surface speed for a cast-iron lap used for finishing are about right. A high surface speed causes the lap to wear out without cutting as rapidly as it should. Many toolmakers make the mistake of running laps too fast, often causing unsatisfactory work.

For light lapping the work can be held by hand but with a heavy roughing cut it is best to hold the work with an ordinary lathe dog, care being taken to see that the dog is not clamped so tightly as to spring the work out of shape. Lead laps should be split to compensate for wear, and the spindles should have a groove cut along their entire length to prevent the lap from turning.

Before testing with a size plug the work should be washed out with benzine or gasoline to remove all traces of the abrasive material, a few grains of which will wear the size plug below standard size in a surprisingly short time. Washing in benzine or gasoline also brings the work to the same temperature as the size plug, which is important where extreme accuracy is required.

Many toolmakers look on the finishing of jig bushings by internal grinding as a rather uncertain method, whereas it is a comparatively simple process when the following important factors are carefully considered. First, proper selection of grinding wheels; second, correct wheel speeds or at least as near as the design of the machine will permit; third, correct alignment of the headstock in regard to the

travel of the platen; and fourth, proper truing of wheels.

Wheels for internal grinding should be of a medium grit, soft grade and open bond. As a rule the grit should never be finer than 60 grit; in fact a coarser grit can often be used to advantage. Wheels with fine grit cut slowly, fill up readily, glazing and invariably heating the work and causing chattering and other troubles too numerous to mention. In fact the only argument in favor of a fine grit wheel is that it leaves a smooth surface. However, no matter how smooth the surface appears to be, even under a powerful glass, it will have to be lapped to remove the wheel marks for the reason previously stated. When we stop a moment to consider that 0.0005 inch will perfectly lap out the marks left by a 60 grit wheel, there is not much room for an argument in favor of 70, 80, and finer grit wheels.

Fig. 9. Grinding the Holes in the Bushings

For the internal grinding of jig bushings on a Brown & Sharpe No. 2 universal grinder, as shown in Fig. 9, the writer has used aloxite wheels, 1½ inch diameter, ⅜ inch face, 60 grit P grade, D-495 bond, with excellent results, the wheel speed being 12,000 R. P. M. The bushings averaged 2½ inches long, 1¾ inch hole. The holes were rough bored 0.015 inch being left for grinding. The grinding time per bushing, including chucking and truing up, was twelve minutes each and the finish left was good, 0.0005 inch being sufficient to lap out the wheel marks. Reference is made above to the holes being rough bored; this is good practice as the rather rough surface tends to wear the wheel just a little while removing the fire scale thus preventing the wheel from glazing. Once the scale is removed from the hole, the wheel should not glaze readily provided it is of the proper grit and grade.

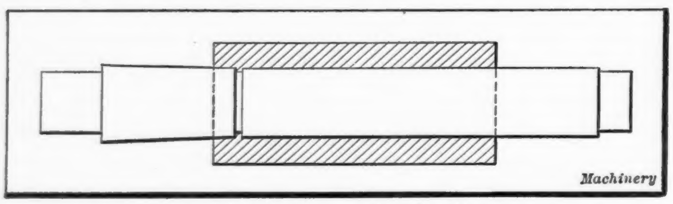

Fig. 11. Arbor for Holding Bushings

Wheels for internal grinding should in theory be run at a surface speed of 5000 feet per minute. This, however, is a general rule open to exceptions. A safe practical rule to follow is to speed up the wheel if it wears away too readily, and to reduce the speed where the wheel shows a tendency to glaze. A little attention to this rule will often save much trouble. The toolmaker should bear in mind the fact that it is much easier to adjust the speed to suit the wheel, than it is to try to keep on hand a large variety of wheels to suit all speed conditions.

Assuming that the work in question is to be done on an ordinary universal grinder, the headstock must be set parallel with the travel of the platen to produce straight holes. A practical way to determine parallelism is to clamp a piece of round stock in the headstock chuck, letting it project from the jaws a little farther than the length of the holes to be ground. This piece should have a groove turned in it for the wheel to dwell in during reversal. This test piece is then ground in the regular way with the wheel used for cylindrical work, the headstock being adjusted by means of its swivel base until the test piece is ground parallel. Before calipering, the wheel should be allowed to grind until very few sparks are visible. When once this test piece has been ground straight the setting can be depended on to produce straight holes, provided, of course, that the swivel adjustment of the headstock and the angular adjustment of the platen are not disturbed. To try to straighten up the headstock by calipering the work while the internal grinding is in process is at best a difficult job, and the operator is never quite sure of accurate results.

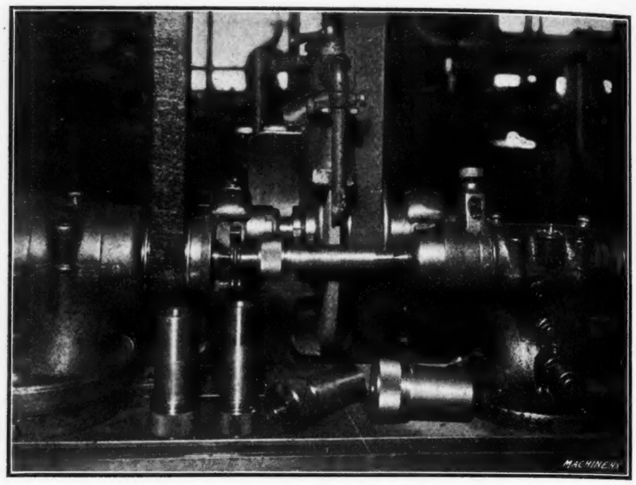

Fig. 10. Grinding the Outside of Slip Bushings

It is common practice to true wheels for internal grinding with a diamond fed by hand, using the eye as a guide. This is poor practice as the wheel is seldom turned parallel, one edge being left to do all the cutting, which, of course, glazes it readily. A more practical way to true these comparatively soft wheels is to feed them past the end of a carborundum rub, in 20 grit H grade. The rub can be held in a suitable holder strapped to the platen of the grinder, or held firmly by hand against the end of the work. As a carborundum rub shows high efficiency when used for this purpose and costs practically nothing as compared to a diamond it is worth considering.

In holding work in the chuck for internal grinding, it is well to exercise due care to see that the work is not clamped hard enough to spring it out of shape. As a rule it does not require much pressure to hold work of this nature as the grinding cut is comparatively light. Attention is again called to Fig. 9 where it is seen that the chuck used in this case is of the variety commonly used on tool lathes. It is my opinion, based on practical experience, that this chuck is an improvement over the chucks commonly supplied with universal grinders, as it is more substantial and has reversible jaws which can be used independently or universally.

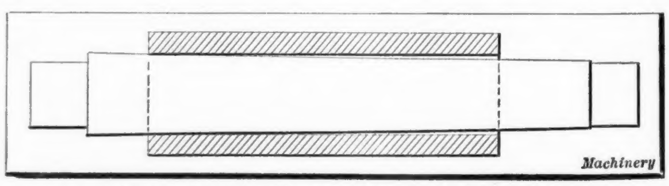

Fig. 12. Improper Fit of Bushing on Ordinary Arbor

As it is general practice to grind internal work dry a certain amount of expansion from frictional heat is always present. For this reason considerable care has to be used in calipering the work with the sizing plug. As the plug is many degrees cooler than the work it is liable, on being inserted, to contract the bushing suddenly, causing bushing and plug to "freeze" together firmly. This can be avoided by cooling the work with a plug that is known to be undersize before calipering with a plug of the desired size. The final calipering should also be done with a plug that is undersize to allow for the final finishing by lapping.

When a wheel of 60 grit is used, a hole one inch or under in diameter should be left approximately 0.0005 inch under size. This amount is sufficient to lap out the wheel marks and leave a dead smooth mirror finish to the hole. This is a general rule based on the fact that a certain amount (in this case 0.00025 inch) is enough allowance to lap out the marks left on a surface by a grinding wheel, and that should suffice for all holes regardless of size. With comparatively large holes, one and one-half inch diameter or over, it is better, however, to make allowance for finishing, owing to the fact that the area of contact of wheel and work is generally not so great and the ground surface is not quite so smooth.

In regard to the external grinding of bushings, there are two important points that should be given consideration,

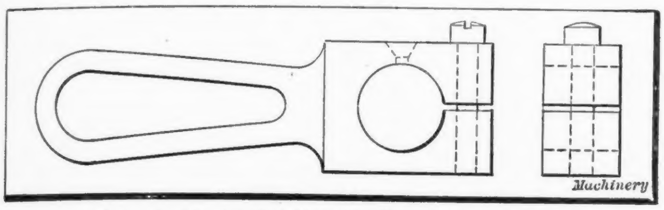

Fig. 13. Lap for Finishing Outside of Slip Bushings

viz: the selection of wheels and method of holding the work. The wheel should be fast cutting and at the same time it should hold its shape and leave a good finish—not the painfully fine finish that delighted grandfather while experimenting with the toolpost grinder, but a good dead finish from which the wheel marks can be readily lapped.

For this work in connection with a Brown & Sharpe No. 2 universal grinder I have obtained excellent results with an aloxite wheel 12 inches diameter, ½ inch face, 5 inch hole, 405 grit, N grade, D-497 bond, the wheel being run at a speed of 1800 R. P. M. In grinding some slip bushings as shown in Fig. 10, the finished surfaces averaging 1½ inch diameter, and 2½ inches long, a work speed of 75 feet per minute was used. The traverse feed of the work was the fastest that this machine was capable of giving in connection with the above work speed, and was approximately an advance of one-fourth the width of the wheel for each revolution of the work.

The finish was excellent and the grinding time for each bushing, removing 0.012 inch, was five minutes. This was accurate work, 0.0004 to 0.0005 inch being left for the final finish by lapping. The above wheel is known as a combination grit, in a medium soft grade and an open bond, and I consider it a great improvement over the hard bonded straight grit wheels used in many toolrooms.

The above work was not done with the idea of establishing a record for this class of grinding, but the object was to show a grinding machine operator what could be done in the line of cutting down production costs by the use of a modern grinding wheel. His time for grinding the same bushings, using a wheel in straight 60 grit, M grade, made by a reliable manufacturer, was fifteen minutes each. He had to use a fine traverse feed, the finest that the machine was capable of giving with a 65 feet per minute work speed to get the desired finish, and to avoid chattering and undue heating of the work.

When a number of bushings are to be ground one after another it is best to mount them on arbors of the same length when practicable to do so, thus saving considerable time generally spent in re-setting the platen, which has to be done whenever the tailstock is moved to accommodate arbors of different lengths. An arbor for holding bushings should be made as shown in Fig. 11. The straight part should be a good fit in the bushing, a slight taper on the remainder of the arbor being sufficient to prevent the bushing from turning on the arbor. When bushings are held on an ordinary arbor or mandrel the operator is never quite sure that the hole and the outside of the bushing are concentric, as one end of the arbor owing to its taper does not quite fill the hole. This is illustrated in Fig. 12. Both Figs. 11 and 12 are somewhat exaggerated to illustrate the principle.

In grinding lining and solid bushings due allowance must be made for a driving fit in the body of the jig. There are three methods in common use for making driving fits on this class of work: First, grinding the bushing until the lower end just enters the hole, the bushing being slightly tapered to bring it to a snug fit when pressed into place; second, grinding the bushing straight for its entire length, leaving it just enough oversize to make a good driving fit; and third, grinding the bushing for nearly its entire length just enough oversize to make a good driving fit, and grinding about one-eighth its length just enough undersize to enter the hole.

The first method is not considered strictly first class practice as the bushing contracts more at the top than elsewhere owing to the taper which leaves the hole in the bushing tapered. The second method is very poor practice as the bushing is very liable to cramp while being forced in place which results in an unsatisfactory job as the hole in the jig is generally sheared by the sharp end of the bushing. The third method is correct as the part that is ground to fit the hole acts as a pilot, thus insuring the proper starting of the bushing, and the body being straight insures even contraction.

In making allowances for driving fits 0.001 inch for each inch diameter of the bushing is considered practical where the holes are one inch or over, and where the holes in the jig are bored smooth. If the holes are rough bored a more liberal allowance is required. After the lining bushings are driven in place they require re-lapping as they always contract a little.

The outside of the slip bushings should be finished by lapping to a dead smooth finish as otherwise they will soon wear loose. This should never under any circumstances be done with emery cloth, but with a cast iron lap as illustrated in Fig. 13. The abrasive used in this case should be of flour grit with lard oil as a lubricant, the abrasive and oil being applied through a hole in the top of the lap. The work should be lapped with a regular even motion to insure its being straight, and should be brought to the temperature of the room by being cooled in benzine or gasoline before testing for a fit. The lapping should be carried to a point where the bushing is a wringing fit in its liner, but not tight enough to stick when left alone for a moment.

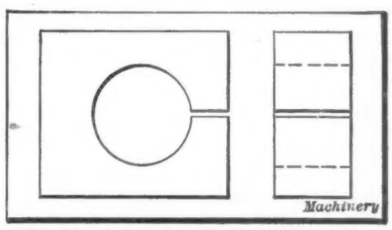

Fig. 14. A Cast-iron Lap which may be used in Emergency Cases

The lap shown in Fig. 14 is often used in an emergency; it is readily made from cast iron and held with an ordinary machinist's clamp. It is practical but not as handy as the lap illustrated in Fig. 13.

After the grinding and lapping of the slip bushings is complete, their tops can be finished by lapping on a carborundum stone, in medium grit, wet with gasoline. A regular motion should be used across the face of the stone without turning or altering the relative position of the bushing. This lapping gives the bushings a workmanlike appearance, and as the dimensions stamped are left black from the action of the fire in hardening, they can be read at a glance.

* * *

In a brief article in *Canadian Machinery*, Mr. Charles T. Main emphasizes a point on which there is a great deal of narrow misunderstanding. Many men possessing technical knowledge seem to believe that they serve their own best interest by keeping it to themselves, whereas, as Mr. Main says, an engineer possessing information, not of a private nature, of benefit to the profession in general, should be broad enough in his outlook to publish it for the benefit of his brother craftsmen. He will find on looking at the matter even from a selfish point of view, that he will not be the loser, for it will bring him into greater prominence and call attention to the fact that he is the man to be employed or consulted in work involving this particular experience. Such men should always be glad to impart to others any information available.

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FINE SCREW THREAD STANDARDS

The Navy, U. S. or Sellers standard screw threads have been widely adopted in America, and are satisfactory for the general run of machine work. They have been used for years in the construction of locomotives, cars, steam and gas engines, mining machinery, farm machinery, etc. But satisfactory as the U. S. standard has been, time has shown that it has limitations of use. The automobile is the most prominent example of a highly developed machine in which the need of finer screw threads was manifested. The jar and vibration incident to high speed and rough roads loosened screws and nuts threaded to the comparatively coarse U. S. system, and finer screw threads were required to prevent loss of parts and rapid deterioration. The French car manufacturers recognized this fact early in the development of the automobile.

In April, 1906, the Association of Licensed Automobile Manufacturers adopted a fine pitch screw standard ranging from 1/4 to 1 inch diameters inclusive, and varying by sixteenths to 3/4 inch and by eighths to 1 inch. This standard was extended to 1 1/2 inch diameter June, 1911, by the Society of Automobile Engineers, the successor of the A. L. A. M.

The need of a fine pitch screw thread system to supplement the U. S. system is also being felt in the machine trade generally. In order to provide for this need it is proposed to adopt the S. A. E. standard and extend it upward to say 4 inches diameter in harmony with the pitches from 1/4 to 1 1/2 inch now existing. Replies to a circular letter sent by MACHINERY to the machine building trade indicate that many concerns have adopted the S. A. E. standard screw threads where fine pitches are required, and would gladly use them for most purposes in larger sizes if they were provided.

The extension and general adoption of the S. A. E. standard would undoubtedly simplify the special thread tool problem for the tap and die makers and relieve them of making many special fine thread taps and dies now demanded. The general adaptability of the two standards is set forth in an extract from a letter from a well-known builder of special machinery:

"The A. S. M. E. and S. A. E. standards for diameters and pitches of screws adequately supply our wants for screws of fine pitches. We rarely find the necessity for any finer pitches in the diversified types of machinery and devices that we are called upon to design or construct, and this occurs only when some peculiar condition of design demands it. From our observation and experience in the design and construction of typewriters, sewing machines, adding machines, tabulating machines, type casting machines, ticket vending machines, auto capsule machinery, knitting machinery, Lanston pneumatic keyboards, etc., we can see no reason why another standard of finer pitches than those obtainable in the A. S. M. E. and S. A. E. standards should be established."

* * *

THE INFLUENCE OF SHOP CONDITIONS

In a comment on the value of well-equipped shops and pleasant working conditions, the *Engineer* (London) remarks that good machine tools mean good workmen to run them. A manufacturer of machinery who had recently reconstructed his machine shop, converting an old-time, dingy shop into one containing the best equipment, arranged and lighted so as to provide for the highest efficiency, stated that he found it much easier to obtain high-class workmen as soon as it became known that they were to operate high-class machine tools.

It is a mistake to believe that all machine operators work for wages only. Many men operating machines in obscure corners of a shop take considerable pride in the work they do, and they enjoy an opportunity to use the best and most accurate machines. Another of the erroneous, old-time ideas which are apparently giving way to a sounder appreciation of the workman's feelings, is that the average machinist, having to perform work in which he cannot possibly keep clean, does not care whether his surroundings are clean and comfortable or not, but is satisfied to work under conditions of any sort. The new plants being erected all over the country show that employers are realizing the value of light, airy and comfortable workshops, and that the additional investment required is money well spent, as it increases the efficiency of the men and lessens discontent, which is the most subtle cause of inefficiency the manager has to deal with. Other conditions being equal, the firm with a clean, light and well-equipped plant will have much less difficulty in getting along with its workmen than one with a dark and dirty shop. It is not without reason that the industries where labor troubles are most frequently encountered are those where the workmen are employed under unsanitary or uncomfortable conditions.

* * *

INVESTMENTS IN UNDEVELOPED INVENTIONS

If the history of "frenzied finance" and dishonest promotion is ever accurately written it will include many cases of patent exploitation wherein inventors and investors were fleeced by smooth-tongued sharpers who promised to develop and market valuable inventions. Some of the most ingenious discoveries and mechanical designs of the times are hopelessly tied up in litigation resulting from the organization of companies and sale of stock before the inventions were developed.

Capital is necessary to place most inventions on the market, and no matter how meritorious a device may be, considerable argument and persuasive ability on the part of some one having faith in it are generally required to obtain the necessary funds from capitalists. The reluctance of capitalists to invest in unknown possibilities is not shared by clerks, bookkeepers, laborers, servant girls and others eager for large returns on small investments, and this fact is shrewdly turned to advantage by promoters who paint in bright colors the probable returns, quoting perhaps the experience of the original investors in telephone stocks as an example of enormous profits yielded by an invention. Inexperienced people who turn over their money for investment in stocks whose value is problematical are too often bitterly disappointed.

A safe rule to follow is to invest nothing in an undeveloped invention unless you have first-hand knowledge of its scope, its novelty, the probable market, and the character of the men who are promoting it. Even when you possess this knowledge the chances for failure are many, and the investment should be made with full appreciation of the possiblity of loss. Widows, orphans and others whose capital is their only resource should steer clear of mechanical promotion schemes generally. Although not usually conceived with the dishonest intent characteristic of mining schemes, they are nevertheless hazardous investments, quite likely to result in loss.

STANDARDIZATION OF MACHINE TOOL PARTS

It is a proper function of the engineer to conserve as well as to produce. Production with waste is abhorrent to the engineer who fully appreciates his economic relation to the manufacturing world. In fact, engineering is the science of producing efficiently, which means the elimination of false movements and waste effort, the utilization of waste products and the substitution of mechanical power for human muscular effort. The elimination of waste carried to the logical end in engineering work would put an end to competition, but that is a condition of society too far removed from present possibilities for serious consideration now. What we can do is to work for those results which in a competitive world may be agreed on as being for the common good.

In the manufacture of machine tools there is little in common as regards sizes and shapes of those parts in the design of engine lathes, planers, shapers, drilling machines and other so-called machine tools made by the various builders for which interchangeability is highly desirable. It is plain to any unprejudiced person acquainted with the conditions of use that certain standards might be adopted by machine tool builders with advantage to themselves and their customers.

For example, take the floor plan of a dozen different makes of sixteen-inch lathes, and it will be found that, although the variation may be little, practically twelve different layouts of foundations will be required. This is a wasteful and undesirable condition, and it would seem that two foundation plans, one for light and the other for heavy designs, should suffice. Surely this is a difference on which it should be comparatively easy to reach common ground for agreement. A similar understanding might be applied to the spacing of bolt holes in countershaft hangers, and any other features affecting the installation.

The more vital matters on which agreement is desirable are standards for lathe spindle noses, dimensions of tee-slots, direction of feed for a given direction of rotation of a feed handle, general position of handles, dimensions and taper of taper shanks and sockets, number of threads per inch of lead-screws, etc.

The matter of agreement of lathe spindle noses is so important that some manufacturers adopted private standards years ago, and specify them when ordering new equipment. One system that has proved satisfactory is the common U. S. standard bolt screw thread sizes. With this system, chuck and faceplates can be sized with standard taps thus simplifying the home making of special lathe attachments.

The Society of Automobile Engineers has worked out several important improvements in manufacturing conditions by which useless duplication of sizes of stock parts have been eliminated. The work of this society is most commendable and constitutes a worthy example for other societies and associations of manufacturers, to imitate.

* * *

THE VALUE OF COST SYSTEMS

In speaking before the American Society of Swedish Engineers recently, Mr. H. L. Gantt, of scientific management fame, pointed out that there are two distinct objects to be accomplished by cost systems and records of factory performances. One purpose of a cost system should be to enable those occupying responsible positions connected with the production to obtain such information as may enable them to devise new and better methods and improve old ones, and to have definite information at hand showing to what extent the new methods actually are more economical than those of former practice. In some shops, however, Mr. Gantt found that the cost system was not kept with this object in view. Very few people connected with the production end of the factory were permitted to make use of the data recorded, and the cost system merely afforded those in charge an opportunity for criticism and fault-finding. No effort was made to devise more economical methods, or to locate the trouble in a systematic way when one month's performance did not come up to that of a preceding month. The executive used the record merely to hold up before his superintendent and foremen, telling them that they did not run their departments as they should.

A cost system run in this way is almost worse than useless; it creates discord and does not serve to increase production. The real purpose of such a system should be to show at any moment if production is falling behind; and a systematic effort should then be made to find the cause, not merely by blaming an individual, but by locating with accuracy the exact conditions which are the cause of the decrease. These conditions may be beyond the control of any of the persons ordinarily blamed. In a machine shop they may be due to hard castings or other defects in the material supplied to the department. They may be due to improper heating and ventilation of the plant. They may be due to unavoidable changes in the personnel. Whatever the cause, it should be ascertained; and unless the cost system accomplishes this, it is of little value because merely blaming a man does not enable him to remedy a defect. He must first find the cause, and the cost system should help him to do that.

Of equal importance is the function of the system which enables foremen, superintendents, designers and others vitally interested in production to determine the value of new ideas; and in order that the cost system may fulfill its purpose in every respect, men in responsible positions within the factory must be given access to the cost data compiled.

* * *

THE PATENT THAT GEORGE DIDN'T TAKE OUT

BY A. P. PRESS

George was a good toolmaker, and when he was not making tools he was playing whist, and although he was an expert at both, I think his abilities in the whist playing line rather lapped over his toolmaking capacity.

Now we have all played whist, and when you have a good sized party in the dining room and parlor, the next morning the floor is covered with the scrap punchings where the score is punched out of the cards.

So as they sat at the breakfast table one morning, with the floor covered with chips, Mrs. George said:

"George, why couldn't you put a pocket on the punch, so as to catch all these little pieces? They are awful hard to sweep out of the carpet."

"Sure thing," said George, and that morning after he got a long chip started, and the boss had gone out for an hour, he turned up a pretty little brass sleeve, and soldered it on to the under side of the punch. He put a threaded cap on the end, so he could unscrew it and empty out the punchings.

He took it home that night, and his wife was enraptured. They used it the next whist night, and his friends all complimented him on the success of his invention.

"Why don't you have it patented? There is a fortune in it if you get hold of somebody to push it for you."

When you get the patent microbe started in a man's brain, it is a pretty hard thing to exterminate it, and George went down to see a patent lawyer the next afternoon.

"Yes," said the lawyer, "that is a pretty good thing, but you ought to have a better looking sample than that. You should get a nicer looking punch, and put it on that."

That night after supper, George got busy. First he sent the oldest boy down to the hardware store and told him to get the nicest ticket punch he could find. The kid came back, and George undid the package, took it out, and there was the cutest little punch you ever saw, with a pocket on it to catch the chips and patented some ten years before!

The microbe was exterminated from George's brain.

* * *

A German contemporary publishes an article in which the writer discusses the theoretical principles of the Tesla steam turbine described in MACHINERY, November, 1911, and also referred to in a note in the July number. The German author points out that the efficiency cannot exceed 50 per cent with the construction employed, and on larger sizes the efficiency would be proportionately less.

INDUSTRIAL ADMINISTRATION AND SCIENTIFIC MANAGEMENT—3

CONSIDERATION OF THE MOST IMPORTANT OBJECTIONS TO SCIENTIFIC MANAGEMENT

BY FORREST E. CARDULLO*

Enough has been said to show that laws and economic conditions have a very great effect upon our industries and the efficiency with which they are conducted. Changes in the law which decrease efficiency are usually objectionable and changes are usually more far-reaching and important than most men believe to be possible. While the engineer usually considers such matters to lie entirely outside his work, yet they affect it so vitally that he will before long be compelled to give them his attention, and to apply to them the same hard-headed and rigorous analysis that he now gives to the design or construction of a piece of machinery. When he does, the lawmaker will regard his efforts skeptically, the financier will regard him as a meddlesome bungler, and most men will regard him as a gross materialist without proper regard for the higher things of life.

In the same way that we have previously classified and examined the sources of industrial inefficiency, let us classify and examine the objections which may be raised against scientific management. These objections come from three sources, the employer, the employe and the public.

Objections of Employers to Scientific Management

Taking first the objections raised by the employer, they usually arise either from a misunderstanding of what scientific management is or from a misconception of the fundamental principles of industrial administration. The objection most often raised is that scientific management very greatly increases what some men term the "expense burden" and what others term the "overhead charges." This is true and yet it is not an objection to scientific management if it can be shown that the total cost of manufacturing a given product is reduced by thus increasing the overhead charges. The introduction of a drafting-room or of a pattern-shop into an establishment which has previously purchased such work outside, will increase the overhead charges, but most plants find it cheaper to maintain drafting-rooms and pattern-shops in spite of this fact. If four men are employed, it is just as well to have one of them constantly engaged in planning the work of the other three, and keeping them supplied with tools and material, as it is to have each one plan his own work and run his own errands.

The question of whether scientific management unduly increases the expense burden is one which can only be answered by experience and in the terms of dollars and cents. If the cost of doing a given piece of work is reduced by scientific management, the question of the ratio of the overhead to the direct charges is of no consequence. If, on the other hand, the cost is increased by scientific management no other argument is necessary in order to condemn the system, and the ratio of the direct and indirect expenses is a matter of purely academic interest.

While some employers are willing to admit that the cost of manufacture is reduced when scientific management is employed, they advance the argument that while direct labor may be discharged when it is not employed, the men in the planning department cannot be discharged without destroying the efficiency of their organization, and so must be retained at considerable expense during periods of industrial depression. Similarly, while the wage cost is cut off entirely when men are discharged, the extra fixed charges upon the larger plant usually called for by scientific management, do not cease when times are slack, and that, therefore, in those industries which are particularly subject to periods of depression, scientific management will be a failure, although during periods of prosperity, it may show a reasonable saving in costs of manufacture. To this objection two answers may be made. First, when scientific management shows a gain after taking account of the periods of depression, it ought to be adopted. Second, if scientific management enables a firm to manufacture more cheaply than competitors, that firm will be able to accumulate a surplus so that it can continue to manufacture and store its product when it would otherwise have to be sold at a loss. Furthermore, it will be able to undersell its competitors, will do a fairly large business in dull times, and will therefore be able to operate its business with less attention to industrial conditions than is given by other firms. If scientific management is able to show a saving at any time, the chances are that it will be able to show a saving all of the time.

A third objection often raised to scientific management is that when a shop is run as systematically as this method of management requires, a sudden change in plans is impossible without seriously disarranging the work, so that the rush order or the special job does not receive the attention which it should. The answer to this objection is that scientific management should contemplate all of the conditions likely to arise in the plant and should provide special means for expediting certain work when that is necessary. If such special means are not provided, the system is imperfect and is not scientific management since it is not adapted to the needs of the particular plant.

A great many objections raised against scientific management come from men who have seen shops in which scientific management has been attempted by managers, superintendents or others, who did not understand what it was. Such men have often attempted to combine scientific management with conventional systems, and while they have sometimes developed improvements, they have often fallen into ludicrous blunders. Such blunders cannot be charged to scientific management, and when it is claimed that scientific management has failed in specific instances, it is well to investigate the case, and see whether the failure is one of scientific management or of unscientific management.

Objections of Workmen to Scientific Management—Wearing Out Men

On the part of workmen there is considerable objection to scientific management. I believe that it usually arises from an idea that efficiency lowers wages and throws men out of employment. This objection, however, is rarely if ever alleged, but others are sought to take its place. The first one, and the one worthy of most serious consideration, is the objection that under scientific management men are urged and compelled to work at such a pace that their health and vitality suffers. Now it is doubtless true that men can be overworked in certain industries, but it is equally true that it is very difficult to overwork men in most industries unless the hours are unusually long. What is termed overwork is usually a matter of unsanitary laboring or housing conditions or insufficient nourishment. For instance, a man may be compelled to work in a cramped position or exposed to great heat or poisonous vapors, he may be compelled to eat and sleep in a hot and dirty tenement, or his wages may be too small to buy nourishing food. If the adoption of scientific management lengthens the time during which he is exposed to unsanitary conditions, his health will suffer, but this is not a matter of overwork but a matter of industrial sanitation. Scientific management recognizes the fact that workmen are often exposed to unsanitary conditions, but the scientific method is to change the conditions and not to reduce the amount of work required.

When we come to discuss the trades usually carried out under sanitary conditions, and requiring a considerable expenditure of muscular effort, we will find that the amount of effort required to accomplish a given task may be reasonable for some men but unreasonable for others. Whether a task is too severe or not, depends on the strength and endurance of the individual workman. Tasks possible for a vigorous man are impossible to one who is ill or weak. Men lacking in strength or vigor are not fitted to engage in certain occupations and they should be transferred to other occupations for

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which their physical defects do not unfit them. For instance, a man whose strength is unequal to the tasks demanded of a hod carrier or blacksmith helper may be very well fitted to become storekeeper's assistant or to operate a punch press.

In this connection it must be noted that a man is not like a machine, but that the wear and tear of the body are repaired by periods of rest. So long as the degree of exertion required of a man is not such as to produce discomfort when continued for several minutes, and so long as proper rest periods occur at suitable intervals throughout the day, the man will not be overworked, but after becoming accustomed to his task will be able to continue his work week after week without any diminution of vigor. If he is properly nourished and works and lives under sanitary conditions, such a man will be just as vigorous and long-lived as though he were engaged in some less laborious occupation.

As a matter of fact it does not pay to wear men out. If men are caused to work at such a rate that their vigor diminishes, they will in their lifetime do less work than they would had they worked at a slower and less exhausting pace, and both the industry which employs them and the community in which they live will suffer accordingly. On that account we need have no fear that scientific management intends to overwork men, although in isolated instances men may be overworked under scientific management either because they are not fitted to the task to which they are assigned or because the one assigning the task was not experienced enough or careful enough to assign a proper task.

One of Mr. Taylor's early successes was to increase the amount of pig iron carried by laborers by properly training them for the task. The amount of pig iron carried after proper training and selection was about forty tons against a previous record of ten tons per day. The first laborer trained for this task was a man named Schmidt, and one of Mr. Taylor's critics thinking the task excessive and severe, very justly inquires, "What became of Schmidt?" Mr. Taylor informs me that Schmidt is at the present time well and hearty and still capable of strenuous tasks and financially much better off than he would be had he not been helped by scientific management.

Harder Work without Corresponding Pay

The second objection raised by workmen against scientific management is that the men are expected to "work very much harder" without receiving a corresponding increase in pay. Often by the introduction of scientific management, a man's output will be increased three or four fold while his wages will be increased not more than from thirty to sixty per cent. The average workman feels that under such circumstances his wages should be increased in the same proportion as his output. When, however, we come to analyze the matter, we find that the workman's contention is not true and that he ought not to expect his wages to be increased in that proportion.

When a man receives his wages, he is paid for several things. In the first place he is paid for his time. In order to get a grown man of potential value as a workman to come and sit in an office and do nothing for eight hours a day, or even to amuse himself in some manner, it would be necessary to pay him something, and probably it would be hard to find men willing to undertake such work, if it may be called work, for a dollar a day. In the second place he is paid for his physical effort. Work requiring no knowledge or experience and which merely requires physical effort does not usually command very good pay. Of course it commands more pay than does the mere expenditure of time, but certainly the effort which an ordinary laborer puts forth, cannot be estimated to command more than 75 cents to $1 a day, and I doubt if the average laborer who receives $2 per day would be willing to take a job at $1.50 per day which did not require any expenditure of effort. A third element for which a man is paid is the ability to receive and understand instructions. A fourth element is skill or dexterity, which enables him to perform a task quickly and well. A fifth element is a knowledge of the details of a trade, which is usually attained by experience and observation.

Let us suppose that a man is engaged in the turning of heavy pieces of steel and that by means of scientific management (*i.e.* by furnishing him proper tools, by standardizing the material, and by informing him of the proper speeds and feeds to use) his output is increased three fold. The time required is the same as before. That portion of his wages which he receives for time expended should therefore be the same as before. The effort required is three times as great as it was before. Since, however, the most of his time is expended in watching his machine and only a small portion of it in changing tools and work, the pay which he receives for the effort expended is very small, and the increase in pay due to the increased effort is proportionately small, certainly not more than 25 to 30 cents per day. The dexterity which he has, and the knowledge of the details of his trade, are no greater than before, and these elements do not call for any inccrease in his wages. A larger measure of ability to follow instructions is required, and this element of his pay should be increased. Of the five elements of his pay two require an increase, and three should remain unchanged. Altogether the increase in pay required by the extra effort and by the increased ability to follow instructions is quite modest, and if the man receives thirty or forty per cent increase in wages, he has received all that he can in fairness ask for. The only way in which we can fix a fair rate of pay is by reference to the rates received by other men engaged in substantially similar occupations. The application of scientific management in different industries will result in different increases in efficiency. In some lines a workman's efficiency will be increased only 20 or 30 per cent, while in other lines it may be increased five hundred or even one thousand per cent. If the work done in the two lines is similar, the pay of the workmen is probably nearly equal before the introduction of scientific management, and ought to be equal when they have attained their best efficiency.

Let us take as an example a foundry in which two different molders are engaged, one on light brass molding and the other on heavy iron molding. Let us suppose that each is paid at the rate of forty cents per hour, that the brass molder puts up twenty flasks a day, and that the iron molder puts up two. Let us suppose that as a result of a careful time study it is found that the brass molder can, without tiring himself unduly, put up thirty flasks a day, while the iron molder can put up six. Each man is then working at his best rate, and while it might be possible for him to do a trifle more work, it can only be done at the expense of his physical welfare. If now, the pay of each is increased in proportion to this increased output, it will be seen that the brass molder will get a fifty per cent increase and the iron molder a 200 per cent increase, the brass molder receiving 60 cents per hour, while the iron molder receives twice as much, or $1.20 per hour.

Now, when you come to think over the results of the application of time study in these two cases, it will be plain that if the work of the brass molder was formerly worth 40 cents an hour, that of the iron molder was worth only 20 cents an hour, and it would be highly unjust after the change in conditions had taken place, to pay the iron molder twice as much as the brass molder. In other words, for work requiring substantially the same intelligence, the same effort, and the same training, workmen should receive substantially similar pay, and this pay should be based upon what constitutes a fair wage under the best conditions, and when they have reached their best efficiency.

The same thing which applies in the case of two molders will apply in the case of two different trades in the same industry, or for that matter, in different industries. If the efficiencies of the workmen engaged in two different trades were unequal before the introduction of scientific management, it follows that injustice will be committed if the increase in wages in each trade is made proportional to the increase in output after, in each case, the workmen have attained their best efficiency.

Another way to look at the matter is to treat it as though the workman were selling his labor under the same conditions as any other commodity. Whenever there is a great reduction in the cost of manufacturing a given product, we expect that there will be a corresponding drop in the price, and usually this is true. The cost to the workmen of doing a given piece

of work is the cost of living. The fact that he does a much larger amount of work than he did before does not increase his cost of living, and consequently the cost to him of doing a given amount of the work is materially reduced, being in the case we have chosen, only one-third of what it was before. Under such conditions the employer may reasonably expect that there will be a decrease in the labor cost, and while the workmen should expect to get higher wages, the employer expects with reason, to pay a lower price per piece. When the workman has an opportunity to do a larger amount of work without any increase in the cost of living, and to receive for his work a larger wage, he is in exactly the same position as the merchant, who by reducing his price is enabled to sell a larger quantity of goods in a given time, to turn over his capital oftener, and to make a larger profit in the course of a year, although he makes a much smaller profit on each article sold.

Finally, we must consider that when a man's efficiency is increased as a result of the application of scientific management, only a small part of this increase in efficiency is due to his own effort and that the most of it is due to the study and effort of the employer. Accordingly any gain which is realized must be divided between the employer and the employe, and usually with the public in the form of lower prices, in order that the public may absorb the larger output resulting. If the employe is to receive all the benefit resulting from scientific management, which would be the case if wages were increased in proportion to output, then it would be no object for the employer to utilize scientific management and its adoption would be of no advantage to the community. If the employe realizes a third of the gain due to scientific management, he has had his share, and must recognize that the other two-thirds belong respectively to the employer and to the community.

On being not required to think, but to carry out Instructions

A third objection often urged by workmen against scientific management is that they are not required to think, but merely to carry out instructions. They feel that when they receive complete instructions as to the method of performing work, it places their work upon a lower plane, transforming them from intelligent workmen into automatons. As one man has expressed it, "I like to think I think, even if I don't think." The answer to this is that Americans have in the past laid undue stress on originality and not enough on ability to follow instructions. If ten men are given explicit instructions as to exactly what to do and how to do it, very seldom will it be that one out of the ten will do exactly as he is told. On the other hand, if ten men are given a puzzle to solve, most of them will succeed within a reasonable time in solving the puzzle. The solution of a puzzle or the origination of a method of work really does not require any higher order of intellect than the exact following of a described method, and is, in the majority of cases, a gift of considerably lower social value.

I have had considerable experience in writing out exact directions informing men in the junior and senior classes of an engineering school, how to perform certain experiments—for instance, how to calibrate a gage. Three men out of five when given the directions for calibrating a gage will read them over and then go to work to calibrate the gage by a method of their own, which is usually incorrect. In the same way, it will be found that when a workman is given a piece of work to do, he will perform the work by a method of his own which is usually incorrect, in that it is not the most efficient method. This brings up the question of whether, for his own amusement, a workman ought to be permitted to adopt inefficient methods of work. When it is put in this blunt manner, every workman will admit that he ought to adopt the most efficient methods of work, and when he realizes that his wages are reduced and his employment endangered if he follows inefficient methods, he will usually be perfectly willing to follow instructions.

The use of instruction cards does not, however, take away from a workman the power of initiative. When a workman succeeds in devising a better method of doing a piece of work than that devised by the planning department, his method will be adopted, and he will receive a reward for devising it. If a workman shows himself capable of devising good methods of work, a place will soon be found for him in the planning department in which he can use his superior ingenuity to his heart's content. Because he has been accustomed to the use of the best methods, he will have a very much better fund of experience to draw upon than a man who has always worked in shops in which the workmen devise their own methods, and on that account his work will be of a superior character.

The use of instruction cards does not prevent a workman from thinking about his work, or from striving to originate new methods, in case he has any originality. Instead, when working from instruction cards, he has constantly before him examples of the best methods of doing work, and his experience is very much superior to that of a man who works in a shop where the workmen devise their own methods.

A man who is minded to do so can advance very much faster in a shop under scientific management, provided he is willing to study and learn. To the intelligent workman such a shop is a trade school, which will help him to a better understanding of his trade, and a chance for larger usefulness.

The argument that scientific management destroys the workman's power of thinking is a fallacy, because it assumes that the only thinking which the workman does is in regard to his work. The higher wages which scientific management involves will bring to the workman opportunities outside of his work which he cannot get otherwise. It will give him money for the purchase of books, for the building of his home, for the education of his children and for increasing the refinements of life. Even if it were true that scientific management curtailed the workman's opportunity to exercise real originality in his work, his intellectual life would still be the gainer from its introduction.

The workman's principal objection to scientific management is that he likes to do things his own way, to work as he pleases and when he pleases. Scientific management is objectionable to him because it compels him to change his habits, which is an uncomfortable process. If a workman were trained under scientific management from the beginning of his apprenticeship, and after several years were put to work in an ordinary shop, the change in habit would be just as disagreeable to him. He would object strenuously to being saddled with additional responsibilities while at the same time his pay was substantially reduced. The slipshod methods of his fellow workmen and the general inefficiency of the shop would grate on his nerves, and be ten times more disagreeable to him than the change in habits which scientific management usually introduces.

We must recognize that men are prone to complain and that anything new, especially if it involves a change in habit, will be the butt of the complaint. If they could not complain about scientific management, they would complain about the length of hours or the temper of the boss or the tools furnished for their work.

Scientific Management involves a Change of Habit

The fact that scientific management involves a change in habit which is disagreeable to many men is not a serious argument against it. People who become accustomed to living in disorderly and dirty surroundings find themselves uncomfortable when obliged to clean up and put things in order. Habits of labor which are inefficient are just as objectionable from the standpoint of the social welfare as habits of life which are unsanitary. Coming generations will look scornfully upon those who are inefficient, just as the present generation looks scornfully upon those who are dirty.

The change of habits involved in the adoption of scientific management is, from the practical standpoint, the strongest objection that there is. The minute you can show a workman that it is to his financial advantage to adopt the methods of scientific management, that minute all objections but this will disappear, but this one is ingrained in his temperament and nervous system, and cannot be reached by logic. Habit is one of the easiest things to form and one of the hardest things to eradicate, but even habits and prejudices must disappear at the demand of social welfare.

A great many misguided souls will urge against scientific

management the same arguments which are urged against all other advances of civilization, namely that it impoverishes the imagination, takes the poetry out of life, puts men to work at machine-like tasks, etc. The same arguments are leveled against all improvements. The sanitary dwelling is less picturesque than the thatched cottage; the mowing machine is not so poetical as the scythe; the division of labor which enables ten little minds in combination to accomplish ten times the task that was formerly done by the ten master craftsmen is said to deaden men's souls and to limit their horizon. It is the eternal battle of common sense and the good of the community against selfish sentiment which regards only its own mental pleasure and takes no account of the good of the swarming many that are benefited by industrial advancement.

No Provision for Unions or "Collective Bargaining"

Another and very valid objection which workmen urge against scientific management is that it makes no provision for unions or "collective bargaining" as our friends the sociologists prefer to term it. It is undeniable that unions are necessary for the welfare of workmen and that without organized effort it would be difficult for them to maintain satisfactory wages and conditions of employment in the face of the tendency of capital to combine into trusts and associations. If scientific management is incompatible with labor unions, workmen cannot afford to accept it, because when scientific management has been adopted and unions have been destroyed, the whole of the benefits will be appropriated by capital, and labor will receive nothing for its increased efficiency.

Notwithstanding that many of the leading exponents of scientific management are opposed to labor unions, and believe that individual bargaining is one of the essentials of scientific management, this is not true. We can still have agreements in regard to minimum wages, hours of labor, conditions of employment, and many other things which affect the welfare of the workmen. The unions, however, must stop short of making any requirements in regard to methods of work or quantity of output or maximum wages paid or premiums given, because such things are not proper subjects of discussion between the unions and the employer, and because any effort on the part of the unions to interfere in such matters will harm workmen even more than employers.

I believe that the reasons that the advocates of scientific management feel their work to be incompatible with unionism is that many of the unions have in times past interfered in matters which were not properly their concern, and by doing so have harmed the cause of labor. Whether scientific management is largely adopted or not, unions will some day cease to interfere in these matters, because it is contrary to their own interests to do so. Since proper demands on the part of unions do not interfere with the operation of scientific management, and since those demands which would interfere with its operation are contrary to the interests of labor, I cannot see that there is anything incompatible in having scientific management in a union shop, and I believe that any effort to destroy unions when introducing scientific management can only serve to delay the date of its introduction.

Even the most serious objections to scientific management on the part of workmen, however, fall to the ground in the face of the fact that when scientific management is adopted workmen receive from thirty to sixty per cent in increase in wages. Not only will there be an immediate increase in wages as a result of scientific management, but with the extensive introduction of scientific management, there will be a substantial decrease in the prices of all those commodities in the manufacture of which it is generally applied. It is usually found that it is impossible to combat the self-interest of a community for a considerable period of time, and as soon as it becomes apparent that the working class, in common with all members of society, receives substantial benefit from scientific management, the objections to it will disappear and those things which at first were regarded as serious drawbacks, will eventually be deemed to be mere trifles and in some cases be regarded as positive benefits.

Objections of the Public to Scientific Management

From the standpoint of the general public, objection can be made to scientific management if it can be shown that it is inefficient, that it injures the health of the workmen, that it lowers the quality of the product, or that it brings about undesirable social or economic changes. The public does not, however, need to worry about the question of efficiency, because if scientific management is not efficient, it will not be used by manufacturers. Scientific management will for a long time be under very severe scrutiny by workmen themselves and it is unlikely that any harm will come to the physical welfare of the workmen unless in very exceptional cases.

Scientific management does not usually lower the quality of the product. In certain cases quality may suffer, but in most cases quality will improve as a result of scientific management. Sometimes a decrease in the quality of the product is not a serious matter, while at other times it is. If it is, scientific management is prepared by proper inspection to insist on such quality as may be commercially desirable. Whenever the public is disposed to require a certain standard of quality, and is willing to pay for that quality, there need be no fear that the quality of output will suffer from the introduction of scientific management.

The principal objection to scientific management is that it will bring about very important social and economic changes with which our present laws are not capable of dealing. One of the effects of scientific management will undoubtedly be the destruction of the small manufacturer. Scientific management achieves its greatest success in comparatively large plants. Those firms which adopt scientific management and are able to secure successful administrators, will crowd their competitors to the wall, eventually absorbing their business and becoming monopolies. Since our present laws are obviously inadequate to deal with such a situation, it follows that we must have a little scientific management in the lawmaking department of our government if we are to avoid social and political evils from the growth of scientific management.

It may be pointed out in this connection however, that men of the "public-be-damned" class do not take kindly to scientific management. Men who are successful in introducing scientific management are those who recognize their duties, and are prepared to act for the welfare of the community as well as of their workmen and themselves. And aside from this fact those monopolies which will be the outgrowth of scientific management will be less oppressive and objectionable than those which are the outgrowth of high finance, legislative favors, or the cornering of natural resources.

Another economic evil which may result from the adoption of scientific management is the mis-direction of effort which will mark the transitory period while conditions are becoming settled. The cause of this is that by the use of scientific management the output of an industry will be very greatly increased. Sometimes the increase will be so great that the community cannot absorb the entire output at the cost of manufacture. The result will be that certain lines of work will be overdone and we will be some time in finding a rational and proper outlet for the extra productive capacity made possible by improved management.

Social and Economic Effects of Scientific Management

Upon surveying the social effects of scientific management, one is impressed with the idea that scientific management will improve social conditions very greatly and that there are only two economic evils prevalent at the present time that will not be materially diminished by the direct or indirect effect of scientific management. The first of these is the misdirected application of capital which results in potential overproduction in certain lines of industry. The second is the diversion of capital from industry for private pleasure. As an example of the first evil, I may cite the textile industry where capital is invested to such an extent that the mills are capable of filling all demands for textile goods when working at only a fraction of their capacity. Examples of the

second evil are unnecessary since they will suggest themselves to most of my readers.

Scientific management must, in the long run, depend for its success upon the habit of mind of those who administer it. We think of the scientist as being a man who is, above all things, intelligently honest, who is without passion or prejudice; who is open-minded and determined to arrive at the truth. The scientific habit of mind is the only one compatible with the administration of scientific management. The man in authority must divorce himself from prejudice, from preconceived notions and snap judgments, and from everything which will turn him aside from the truth. In adopting scientific management, he must recognize certain great principles; some of which are economic, some of which are psychological, some of which are ethical, and some of which are merely physical.

An industrial establishment is merely a part of a great economic system. Recognizing this, the employer will see that if the establishment does not minister to the needs of the community, it is useless. Not only must its product be valuable, but is work must be carried on in such a way as not to harm the community. Work which is carried on at the expense of a part of the community, in order to benefit the remainder, cannot be justified. By such work I mean work carried out under dangerous or unsanitary conditions, or where the wages paid are insufficient to maintain the community standard of living. It may be cheaper to carry on work in that manner, but the moral sense of the community will not in the long run permit of it, and scientific management recognizes the fact.

The interests of all men engaged in a given industry are identical. A certain school of thought is accustomed to regard the labor situation as a war, in which employer and employe are striving to obtain an advantage over each other, each striving to secure from the other the largest possible proportion of the total returns of the industry. Scientific management recognizes this to be an error, and knows that cooperation between employer and employe is essential. It recognizes not only that the employer must purchase the cooperation of the employe by high wages and fair treatment, but also that he must cooperate with the employe by assising him in every way to become as efficient and valuable as possible. Each must cooperate with and assist the other, and must purchase by fair dealing and generous attitude the cooperation of the other.

The greater the productivity of a community, the more prosperous the community will be. High wages and restricted production are incompatible, and only by achieving the highest efficiency can the greatest prosperity be reached. There may be, however, overproduction in certain lines of work, because too much capital or too many men may be engaged in that line. This does not mean that too many men are employed or too much capital is available. It merely means that men are employed in the wrong industries and that capital is invested in the wrong lines. Consequently, the application of scientific management to all establishments engaged in one particular industry, may result in throwing the industrial system out of balance by producing more of one kind of goods than is necessary.

Conclusion

Work well done under proper conditions is interesting and healthful when the worker is healthy and well nourished. Work under unsanitary conditions is unhealthful. A poorly-nourished workman is always overtaxed by relatively small tasks. Unsatisfactory surroundings and slovenly work results in nervous strain which breaks down the workman's health. Men differ mentally and physically in innumerable ways, and each workman must be studied in order to discover the most useful place in which to put him. He must be put in that place where his abilities will be utilized to the utmost.

A careful study of a piece of work by a man of scientific habit of mind, having at his command the knowledge of a large number of expert workmen, will result in the development of methods of doing work which are far superior to the methods usually employed. Workmen naturally perform their tasks in improper ways as a result of habit. In order to have them perform the tasks in a proper way they must have supervisors to see that they form correct habits of work, and they must be encouraged by extra pay to continue in these habits.

The cooperation of workmen must be secured by persuading them that the employer has abandoned the attitude of war and that he is willing to divide the results of his improvements with the men whose cooperation makes these improvements possible.

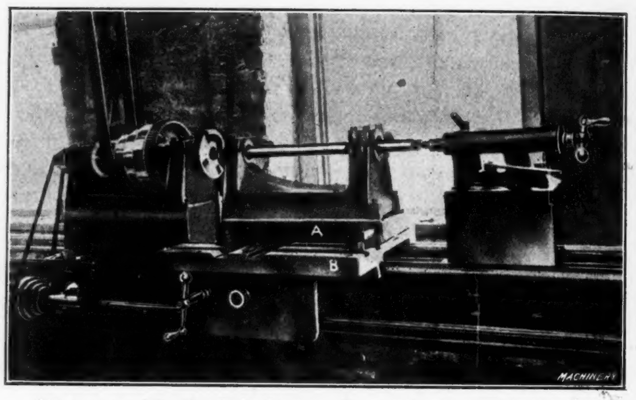
Finally, the benefits of scientific management are so many and so varied that not only employers and workmen but the community generally will participate in them. It is therefore proper not to object to scientific management but rather to study the ways in which we can eliminate the evils which may possibly come from its use, and take advantage of the benefits just as we take advantage of the benefits of railroads, printing presses and steam power, in spite of the manifold evils which some men thought they foresaw as a result of their introduction.

* * *

BORING AND FACING THE SPINDLE BEARINGS OF LATHE HEADSTOCKS

There are various methods used for boring and facing the spindle bearings of lathe headstocks. Some lathe manufacturers use boring machines, while others equip lathes with special fixtures for this purpose. The accompanying illustration shows the method used by the Rahn-Larmon Co., Cincinnati, Ohio, in boring and facing the bronze spindle bearings for a 20-inch engine lathe.

After the V-guides have been planed, the caps fitted, and the bearing boxes faced on the planer, the headstock is bolted



Fixture used by the Rahn-Larmon Co., for boring and facing the Spindle Bearings of Lathe Headstocks

to a special table *A* provided with ways to fit the V-guides in the headstock. This table, in turn, is clamped to a special carriage *B*, fitting the lathe shears and provided with a slot in its top face, which by means of a tongue on table *A* locates the bearings in the headstock in perfect alignment with the lathe centers.

The boring is accomplished with a boring bar held on the centers, and driven by a dog. Both front and rear bearings are bored at one setting, two cutters being used. The front bearing is 3¼, and the rear, 2½ inches in diameter. The bronze bearings are next faced with a broad-faced fly-cutter, after which operation the bosses of the bearing caps are reduced to the same diameter as the bronze bearings with an L-shaped fly-cutter. All the operations enumerated, as well as clamping, etc., take about 40 minutes for each headstock.

D. T. H.

* * *

Statistics relating to the automobile industry in the United States indicate that, at the present time, this industry is the third in importance of the various industries of the country. There were in April, 1912, 652,500 automobiles registered in the United States. The daily production of pleasure cars alone, during 1911, reached 700 a day. There are more than 25,000 commercial cars and trucks in use and it is estimated that 30,000 of these cars will be manufactured during 1912.

THE MOTOR TRUCK IN MANUFACTURING

ITS UTILITY, ADAPTABILITY, CAPACITY AND ECONOMY UNDER SUITABLE CONDITIONS

BY HAROLD WHITING SLAUSON*

There is probably no place where the motor truck is surrounded by more favorable conditions for efficient operation than in the average manufacturing business. Machines are used throughout for the production of the goods; why should not mechanical power be employed for the transportation of the raw and finished material? No matter how large or how small the plant may be, and regardless of the size, nature, or quantity of the product, a motor truck transportation, delivery, and hauling service *must* show a marked saving in time and money over the horse type, if the former is properly installed and operated under efficient conditions. As power-driven machines have reduced the cost of manufacturing goods, so will motor-propelled trucks lessen the hauling charges for those goods.

These may seem like sweeping statements, but they are attested to by thousands of successful truck installations in hundreds of different kinds of manufacturing businesses. The success of these proves the adaptability of the motor vehicle, for each of these manufacturing lines may require its trucks to operate under conditions absolutely different from any of the others. By means of special bodies and a wide selection of types and sizes of power plant, a variety of combinations can be obtained, the proper selection of which will allow almost any operating condition to be fulfilled. A few years ago the motor truck cost more to install and to operate than the horses and wagons required to perform the same amount of work, and this excess expenditure was charged to advertising; but the modern motor truck has been brought to the point where it can show an actual dollar-and-cents saving, and even on this one merit alone can the mechanical means of transportation compete with the horse. Figuring interest on the investment at 6 per cent, depreciation at 10 per cent, chauffeurs' wages higher than those paid to horse drivers, and insurance premiums and repairs at a larger amount than would ordinarily be required in practice, the properly-organized truck installation will show a saving of from ten to thirty per cent over the maintenance expenditure required by a horse system.

From an investigation of many installations made by one company, it was found that interest, insurance, garage expenses, and driver's wages constituted a daily fixed charge of $5.32 for a 5-ton truck. This charge, of course, continues whether the truck is in use or not, and remains constant regardless of the mileage covered. Operating expenses, such as those for tires, gasoline, lubricating oil, and allowance for repairs, overhauling, and depreciation amounted to 15½ cents a mile. For a 50-mile day, the total expense would amount to the fixed charge of $5.32, plus 50 times the 15½ cent per mile operating cost, or $13.07 per day.

This strikes the keynote of the secret of a successful truck installation. Inasmuch as the $5.32 represents a fixed charge that is not affected by the distance that the truck travels, it is evident that the cost per ton-mile will be reduced as the daily mileage is increased. A 5-ton truck traveling 50 miles a day has a ton-mile capacity of 250. Inasmuch as there is but little difference between the operating cost of a loaded truck and one running empty, it will be seen that the hauling expense per ton mile may be reduced to slightly over $0.05. This is on the assumption, however, that the truck will be run at full load at all times—a condition which, obviously, cannot be attained in the average installation. If the truck is run loaded in one direction and returns empty, the hauling cost per ton-mile will be doubled.

There are, consequently, four broad, general conditions to be met in order to secure the most efficient installation. The truck must be selected with due regard to its capacity; its work must be so laid out and routes so arranged that but a minimum amount of time will be spent in idleness, and its active hours must be employed in hauling loads approaching as nearly as possible to its rated capacity; its construction must be such that the necessity for repairs will be infrequent; and its design must be so simple that it may be handled and overhauled by the ordinary intelligent driver or machinist, thereby eliminating the expenses of high-priced help. The fulfillment of the first two of these conditions rests with the purchaser, with the co-operation of the manufacturer of the truck, while the last two depend upon the truck builder and designer—but with the necessary co-operation of the purchaser.

Fig. 1. Pierce-Arrow Auto Truck carrying Machinery to the Freight Depot

The selection of a truck with regard to its capacity is an important consideration, but one too often overlooked. A 5-ton truck should not be purchased to conduct a 2-ton hauling business, unless expansion in the near future is to be provided for. To haul two tons in this case will cost nearly as much as to haul five, and such an installation would probably show a loss. Of course, it rests with the purchaser as to whether the expansion of this end of his business will, in the future, call for larger trucks, or a greater number of small vehicles, but the installation departments of the truck factories will help him with this problem.

While it is necessary that the trucks should be run fully

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loaded as much of the time as possible, the fact must not be overlooked that loads in excess of the capacity of the machine will cause the ton-mile hauling cost to increase rapidly. In fact, it is probable that to this tendency on the part of owners and drivers may be attributed the majority of the failures of commercial vehicle installations. By a constant 25 per cent overload, the life of the tires may be reduced by two-thirds.

Inasmuch as a high mileage is essential to efficient motor truck operation there should be as little delay as possible in loading and unloading, and trips and routes should be so arranged that the truck may be given an opportunity to take advantage of its speed and large territory-covering ability. But even though the area to be covered by the truck might, of necessity, be restricted to the factory yard, the use of special loading and unloading devices may easily overcome what would otherwise be serious obstacles to an efficient installation. If the factory is situated some distance from the freight yards, and the truck can be utilized to carry the finished products to the point of shipment and to bring back raw material on the return trip, conditions are nearly ideal, and such an installation should show a marked saving over any other arrangement. In fact, an installation that will allow the truck to travel loaded in both directions is so obviously destined to be successful that the only question to be considered is as to which of the many trucks on the market would be best adapted for the particular requirements of the business. Many manufacturing businesses employ one or more trucks to do "odd jobs" around the yard. As work of this type will consist, probably, in moving heavy machinery or other material, and in traveling under load from one building to another, trucks used for this purpose should show good returns on their investment.

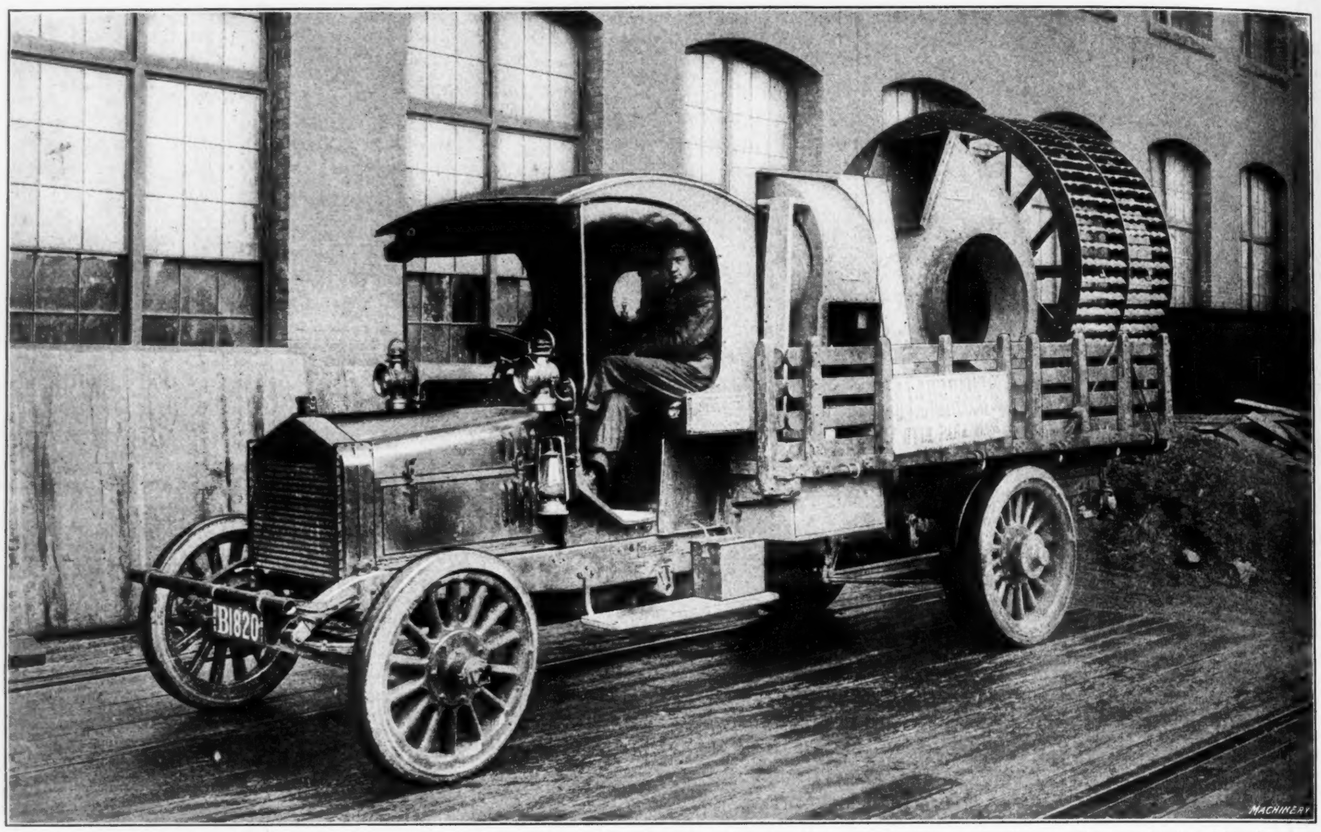

Fig. 2. Pierce-Arrow Five-ton Worm-driven Truck used by a Large Manufacturing Concern for carrying Heavy Castings and Large Parts of Machinery

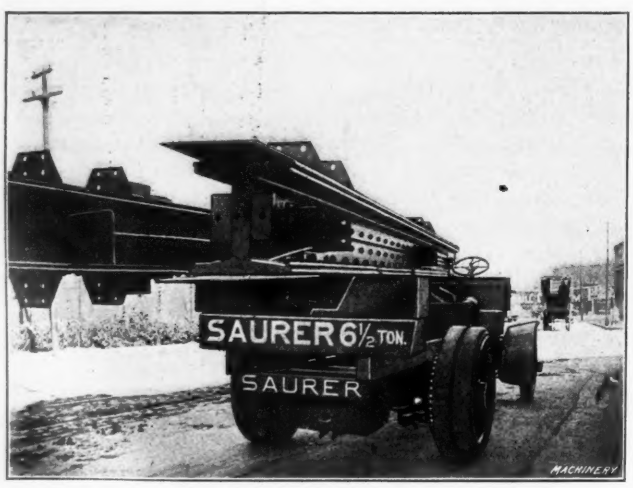

Fig. 3. A Six and One-half ton Saurer Truck hauling Steel Girders for an Office Building Construction

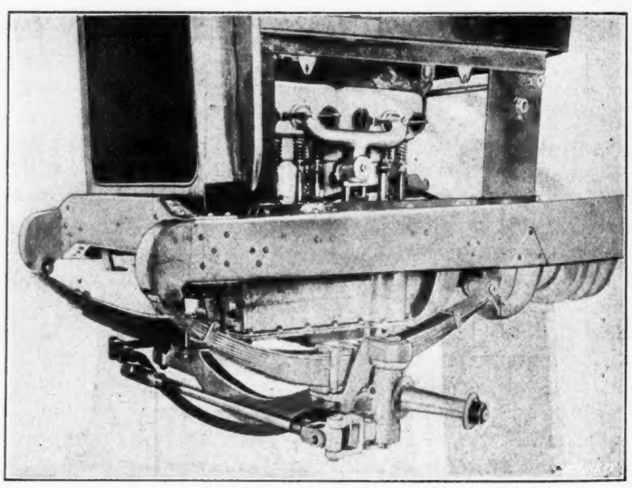

Fig. 4. The Front of a 5-ton Lozier Truck Chassis. All the Vital Parts are properly protected in Case of Collision

The very multitude of chassis sizes and types and body designs from which the purchaser may choose is striking evidence of the variety of purposes to which the motor truck may be put. Special bodies may be obtained to meet certain requirements, and these may be mounted on any size or type of chassis. It is probable that the average manufacturer will find the conventional stake body the type best suited to his needs. This may be mounted on a chassis of the ordinary length when heavy loads are to be carried, or on a chassis of extra-long wheelbase if its regular load is to be bulky or long.

It is not, however, only because of the unusual opportunity to run loaded a large part of the time that a truck will appear to unusually good advantage when used in a manufacturing business. The fact that a motor truck is a *machine* indicates that it will be well cared for, and that unusual

facilities will be already at hand for its overhauling and repair. Probably every tool that would be used in a complete garage and repair shop will be found in the average large factory. There will probably be a large force of men familiar with all kinds of machinery, and consequently the motor truck will not be the "strange creature" that would be the case were it replacing the horse transportation system of many another line of business. This enables the factory to retain its old drivers. Thus a complete garage and repair shop may be installed and equipped in the factory yard at but little additional expense, and the attendant saving in storage and overhauling charges will represent a large item. If the truck installation consists of but one vehicle, it may be advisable for a time, at least, to store the machine in a public garage, but even this will not bring the expense above that figured for a 5-ton truck in a preceeding paragraph, as this charge was included in the estimate.

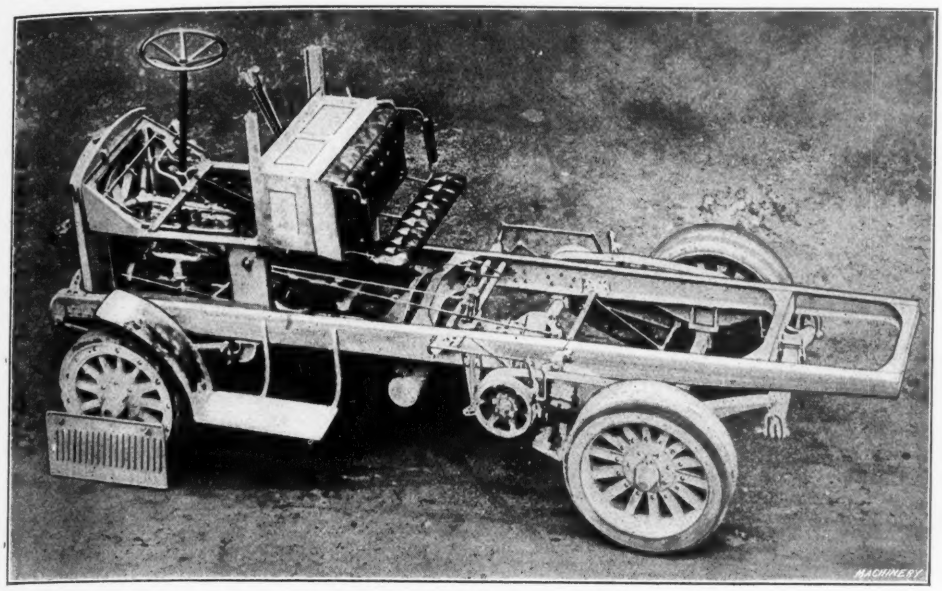

Fig. 5. Chassis of a Five-ton Lozier Truck showing the Accessibility of the Motor located under the Driver's Seat, which can be folded back

If the equipment consists of three or more trucks, it will undoubtedly prove advisable to equip a private garage and employ an expert whose sole duty shall consist in overhauling the vehicles and keeping them in perfect repair. In this case the drivers need only understand the control of the car, and are not required to be experts themselves. Consequently, a considerable saving may be made in chauffeurs' wages, and this forms the third advantage to be found in a motor truck installation in a manufacturing business.

The question of service is naturally an important consideration. No matter how well constructed a motor truck may be, it will require a certain amount of care and attention, and the engine must be overhauled occasionally. If several trucks are used, much of this work may be done at night, and if the power plants are thus kept continually in the top-notch of condition, there need be but little fear of interference with their work during the day. It was not long ago that, in large installations, one truck in every ten was used as a reserve machine. In other words, it was assumed that only 90 per cent of the trucks would be available for service. Today, through better management of the installation, as well as through improved design, the average percentage of idle trucks has been reduced to about two. Some builders have provided removable power plants that can be used to replace the engine that requires overhauling. These power plants are of the "unit" type and include, besides the motor, the clutch, transmission, and, in some cases, the radiator and all electrical equipment. These parts are all attached to the motor or its base and the entire power plant may be lifted out after the removal of two or three bolts. Thus, by the use of but one extra removable power plant, nine or ten trucks may be kept in practically continuous service, and yet each motor may be thoroughly overhauled as often as necessary.

The unit power plant, which includes the transmission mounted on an extension of the motor base, is not used on the majority of heavy trucks—although some of two, three, and even five-ton capacity will be found so designed. The average five-ton truck is chain-driven from two sprockets mounted at each end of a jack-shaft extending from the transmission case and located about in the middle of the frame. There is at least one notable exception to this design, however, in the form of a shaft-driven five-ton truck that employs a worm and gear for transferring the power from the propeller shaft to the floating rear axle. Practically all of the trucks having a capacity of over three tons use the twin, or dual, solid tires on the rear wheels. Such a wheel is provided with one set of spokes, but possesses two rims, thus giving the effect of an exceedingly wide tire. Instead of using one wide tire on each wheel, however, two narrower tires are mounted on the single felly.

The power plants of the larger trucks are similar to many of those used on the high-power touring cars. The ordinary 5- or 10-ton truck is generally driven by a 30- or 40-horsepower motor located in the forward portion of the chassis, either under a conventional bonnet or under the driver's seat. In the latter design, the seat tips back or to the side in order to render the motor easily accessible. The gear ratios of the truck are much higher than are those of the pleasure car employing a power plant of equal size, for the speed of a 5-ton truck should not exceed 12 miles an hour, while that of one of 10 tons capacity should be restricted to 7 or 8 miles an hour. Some 3-ton trucks are designed to attain a maximum speed of 15 miles an hour—and even higher—but the governors used on the majority of the motors restrict their speed to about 1200 revolutions per minute, and consequently the maximum speed of the truck will depend upon the gear ratios employed. On one truck, the governor is attached to the driving shaft, so that the speed of the car itself, rather than that of the motor, will be restricted.

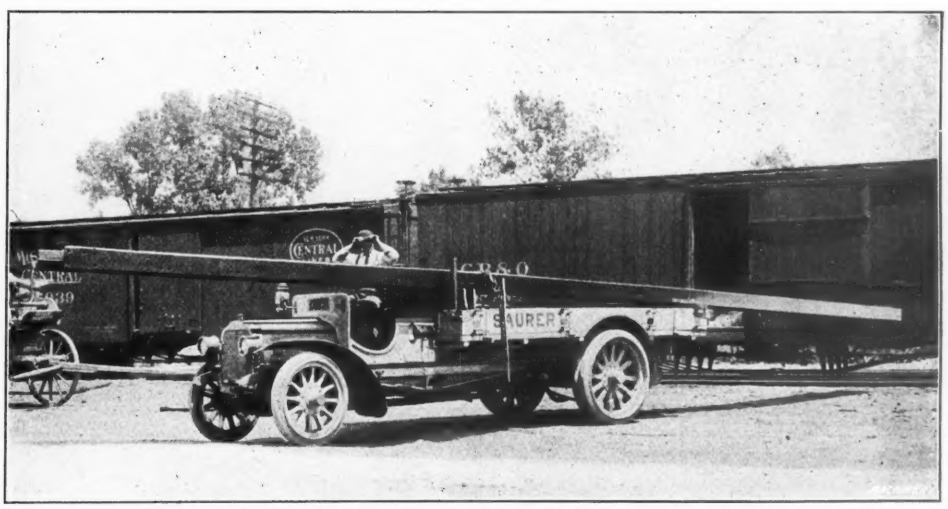

Fig. 6. Six and One-half ton Saurer Truck hauling Long Steel Girders

It is evident that many designers have kept in mind the desire of truck owners to employ former horse drivers—or other men unskilled in handling a power vehicle—instead of

expert chauffeurs, for the modern motor truck is of exceedingly "foolproof" construction. In fact, continued overloading constitutes about the only means—aside from downright vandalism—by which the average motor truck can be injured. By means of heat-treated and other special steels in the motor, transmission, and other parts of the frame and running gear subject to unusual strain or wear, the present-day truck can successfully withstand a remarkable amount of abuse; but there are right and wrong ways of handling even the most invulnerable truck, and many designers have bent their efforts toward eliminating all possible sources of abuse. In some, the spark control lever has been removed and a fixed point of ignition used in its stead, so that the driver cannot run the motor at slow speeds and with closed throttle when the spark is advanced. On other trucks, an automatic spark advance and retard has been installed by means of which the speed at which the motor is operated regulates the point of ignition. In still another design, a spark lever has been used, but instead of placing this on the steering wheel—as is usually the case—it has been located on the dash where it cannot be reached as easily by the driver as can the throttle. It is assumed that there will be less temptation to "monkey" with the spark if the lever is not so conveniently located.

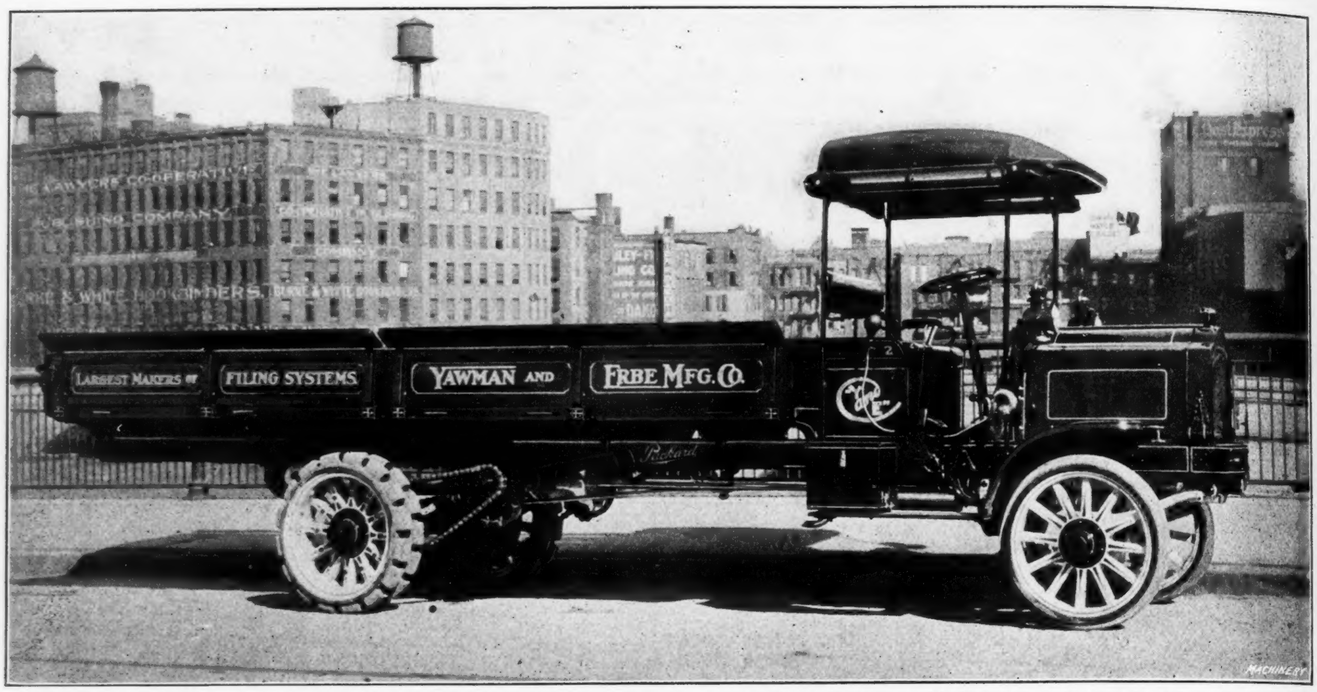

Fig. 7. Packard Truck with Long Overhanging Body at the Rear, facilitating Loading at a Platform. This Truck does the Work of Four Teams of Horses at an Average Cost of $9.92 per Day, or at a Saving of about $10.00

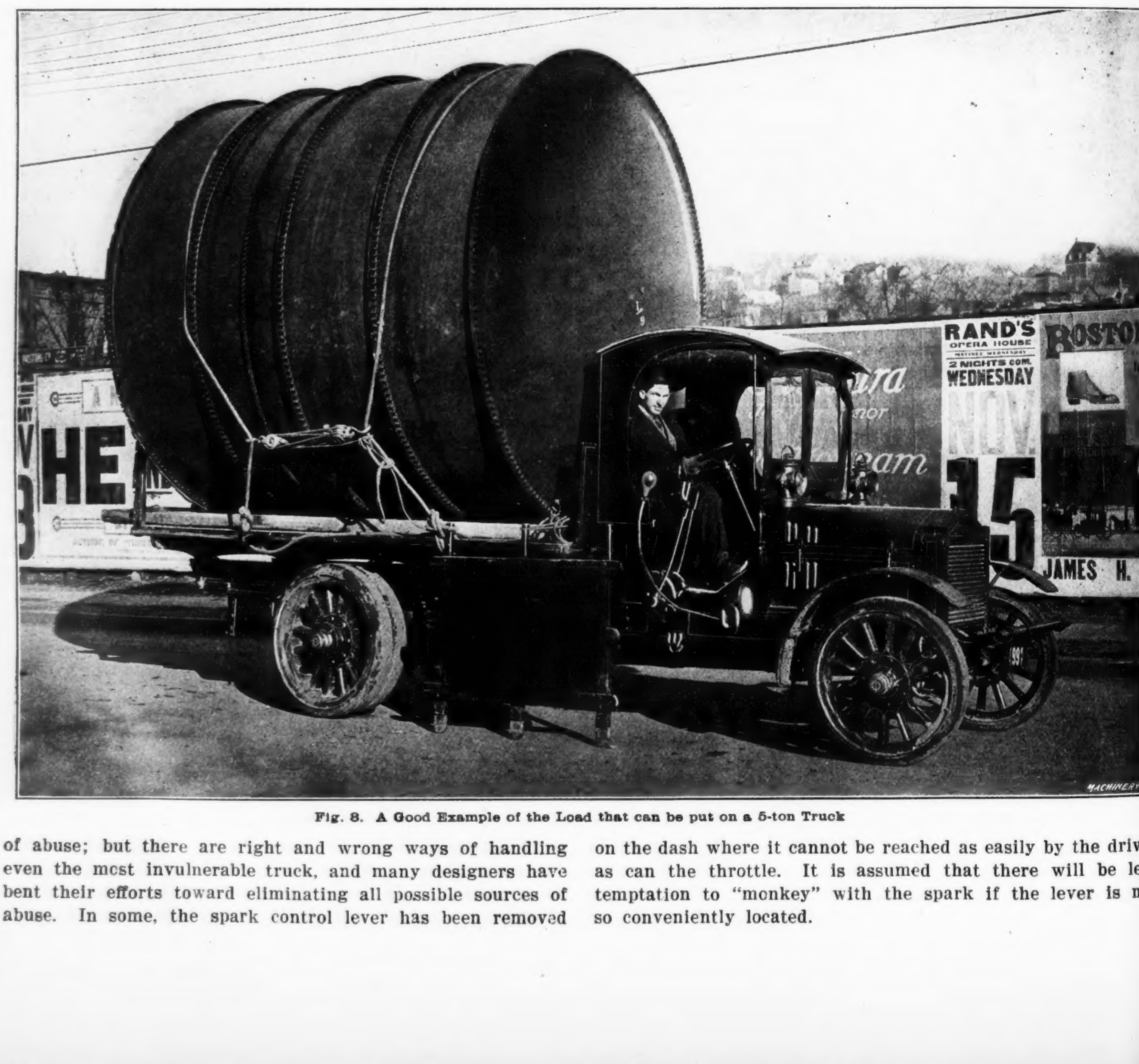

Fig. 8. A Good Example of the Load that can be put on a 5-ton Truck

Although some of the heavy trucks are provided with planetary transmission, the majority employ the sliding type with either the selective or progressive method of shifting—the latter being in the majority. Modern transmission gears are so accurately cut and are made of special steels of so high a grade that it seems well-nigh impossible to "strip" them. As an added precaution, however, some trucks are provided with special devices which render abuse in this direction impossible. On one such device, the gears are in mesh at all times and each is provided with an individual clutch. The gear control lever is used to engage the various clutches, and thus the different speeds are obtained without any actual sliding or clashing of the gears, and the changes may be made without releasing the main clutch. Other designs employ a notched quadrant which prevents the movement of the gear-shifting lever until the main clutch is disengaged. Still a third system allows the gear-shifting lever to be moved, but the gears themselves are not slid into position until the clutch is released. This action is obtained by means of a bar cam which brings the tension of a spring into play against the gear to be moved. A back-cut on the jaws of the positive clutch with which each gear is provided, however, prevents the movement of any of them while the jack-shaft is revolving, and as this jack-shaft will continue to turn as long as the main driving clutch is engaged, the gears cannot be changed until conditions are proper for the shifting.

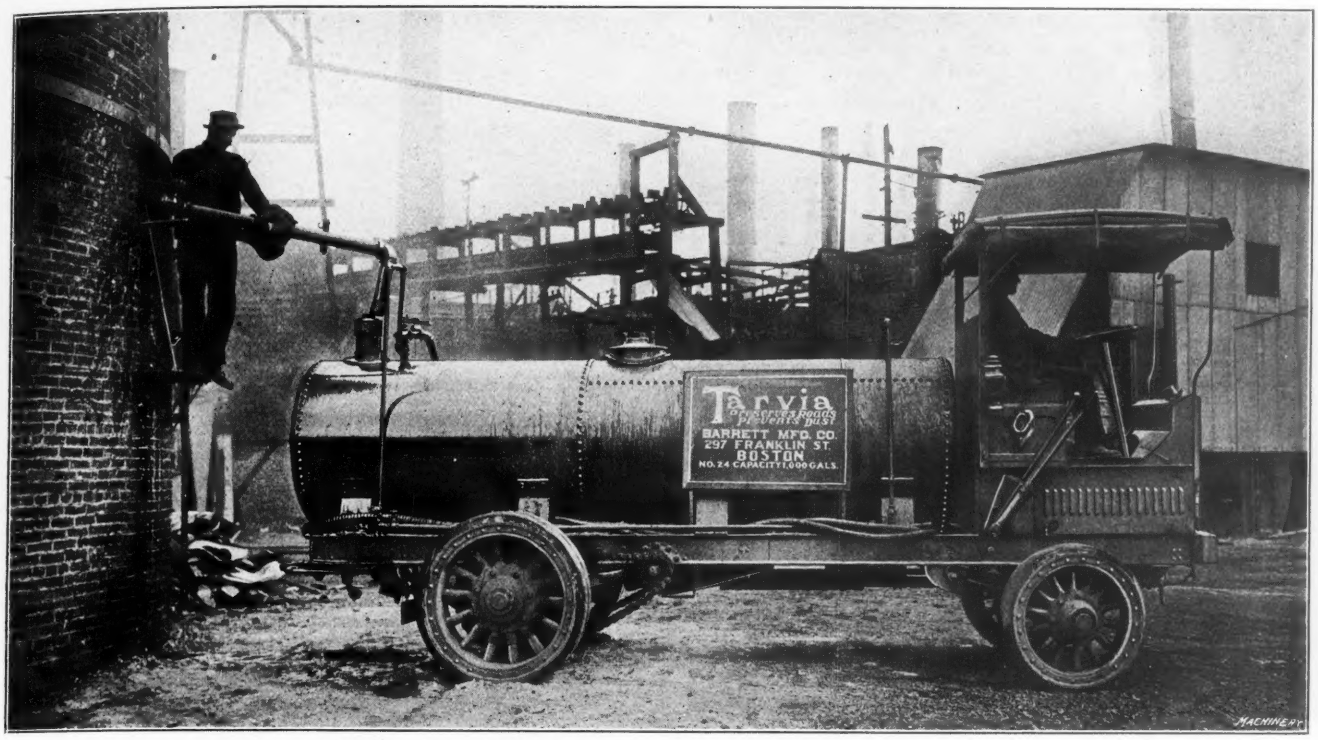

Fig. 9. Alco Tank Truck used for Spraying Dust-laying Oil on Roads

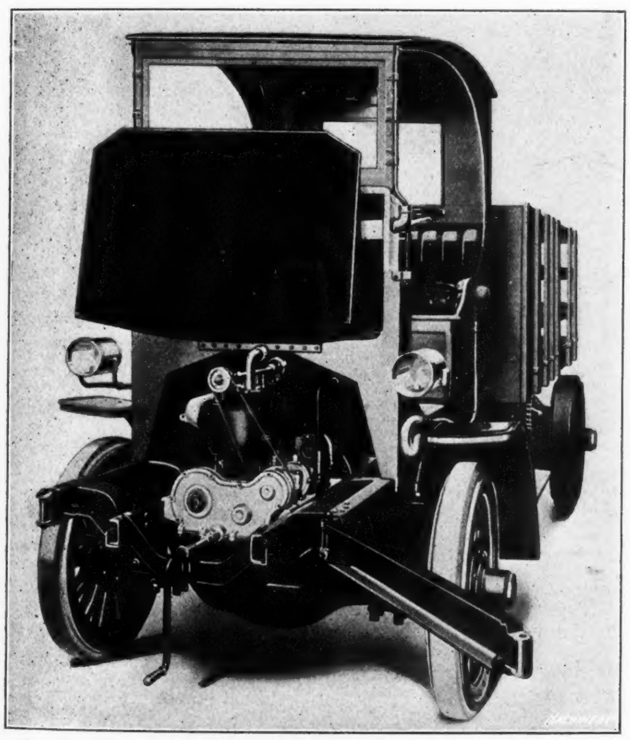

Fig. 10. Removable Power Plant of a Grabowsky Auto Truck ready to be slid out of the Chassis

From 60 to 80 per cent of the load on the modern motor truck is carried over the rear wheels. This insures effective traction and enables the truck to negotiate slippery roads and steep hills with comparative ease. Designers are realizing that, because of its surroundings and the nature of its work, the average motor truck will be subjected to many a hard knock from exterior sources, in addition to those it may receive at the hands of a careless driver. Consequently all vulnerable parts are protected as far as possible from contact with any obstacle which the heavier portions of the truck might strike. For example, a heavy cross-member may be riveted to the forward portion of the frame to serve as a guard for the more delicate radiator, and all of the motor, transmission, and protruding shafts or studs may rest within the confines of the frame proper. On some trucks, the motor sub-frame and radiator are mounted on separate springs to relieve these parts of the shocks and jars of travel that will not be absorbed by the heaviest body springs.

In fact, the modern truck is so well designed and constructed, and there is such a variety of body and chassis types and sizes from which to choose, that the blame for an unsuccessful installation may generally be laid to the purchaser of the truck and his system, rather than to the builder. There are, of course, many problems to be met and changes to consider, but each problem can be solved and all difficulties overcome especially well in a manufacturing business.

* * *

The corrosion of nickel, chromium, and nickel-chromium steels has been investigated by Messrs. J. Newton Friend, J. Lloyd Bentley, and Walter West, of Darlington, England, and the results of the investigation have been placed on record in a paper read before the Iron and Steel Institute of Great Britain. One of the interesting conclusions arrived at is that in certain neutral corroding media, such as salt water, the resistance to corrosion rises with the percentage of chromium. Hence, the employment of chromium steels in the construction of ships seems to be fully justified on this ground alone. Nickel steels appear to be resistant both to acid and neutral corroding media, in proportion to the percentage of nickel.

DESIGN OF A HYDRAULIC INTENSIFIER

A SYSTEMATIC METHOD OF CALCULATING THE DIMENSIONS OF THE DIFFERENT DETAILS

BY J. B. VARELA*

The object of this article is to explain in a simple and direct manner the calculations necessary for designing a hydraulic intensifier that shall fulfill certain specified requirements, and be of correct design, as nearly as possible, from the view-point of the engineer. The specifications that will govern the design may be briefly stated as follows: Required, a hydraulic intensifier to raise the pressure from 1500 pounds per square inch to 4500 pounds per square inch, having a capacity of 10 cubic feet on the low-pressure side. The choice of the materials, as well as of the proper working unit stresses, is left to the judgment of the designer.

In order to ascertain the diameters of the rams and the corresponding lengths of the stroke, it is advisable to tabulate the various possible diameters together with their corresponding lengths of stroke, and then select the most suitable dimensions as dictated by practical considerations.

Large Ram			Small Ram	
Diameter	Area	Stroke	Diameter	Area
21	346.36	49.8	12	113.1
17	226.98	76.1	10	78.54
16	201.06	86.0	9	63.62

The high-pressure cylinder acts as the low-pressure ram, as shown in Fig. 1. This arrangement is the most economical in the use of materials, as well as in the space occupied by the apparatus.

The sizes tabulated indicate fairly good proportions. We will select the third set of possible dimensions and calculate how they balance. The area of the low-pressure ram multiplied by the pressure acting on it must equal the product of the area of the high-pressure ram by the pressure acting upon it plus the excess load required to overcome the friction of the machine. Thus:

$201.06 \times 1500 = 301{,}590$ pounds, the load on the low-pressure ram,
$63.62 \times 4500 = 286{,}290$ pounds, the load on the high-pressure ram.

15,300 pounds, the excess load on the low-pressure ram. This difference is necessary, as noted above, in order to overcome the frictional forces that oppose the motion of the rams.

The volume of the low-pressure cylinder is assumed to be equal to the volume displaced by the low-pressure ram, that is $201.06 \times 86 = 17{,}291$ cubic inches, which is slightly in excess of the required volume. The actual volume of the low-pressure cylinder greatly exceeds this figure, as will be seen from Fig. 1. The length of the stroke is 86 inches, which is not abnormal.

The friction of the packing may be calculated by the following formula:

$$F = \mu P D.$$

in which F represents the force of friction; P, the internal pressure in pounds per square inch; D, the diameter of ram in inches; and μ a coefficient, the value of which depends on the kind of packing used. (Although U-leather packing offers the least frictional resistance, we will use hemp packing in our design owing to the fact that it is easy to replace, cheap to maintain, and that leakage can be readily avoided.) The value of μ for hemp packing may be taken as 0.20. Hence the force of friction against the stationary ram is:
$F = 0.2 \times 4500 \times 9 = 8100$ pounds; and for the movable ram: $F = 0.2 \times 1500 \times 16 = 4800$ pounds; making a total of about 12,900 pounds.

The inside diameter of the low-pressure cylinder is 18½ inches and the internal pressure 1500 pounds per square inch. Using Lamé's formula, we have:

$$D = d\sqrt{\frac{S+P}{S-P}}$$

in which D represents the outside diameter of the cylinder; d, the inside diameter; S, the working unit tensile stress, taken as 8000 pounds per square inch; and P, the internal pressure, also in pounds per square inch. Hence:

$$D = 18.5\sqrt{\frac{8000+1500}{8000-1500}} = 22.37, \text{ say } 22\tfrac{3}{8} \text{ inches.}$$

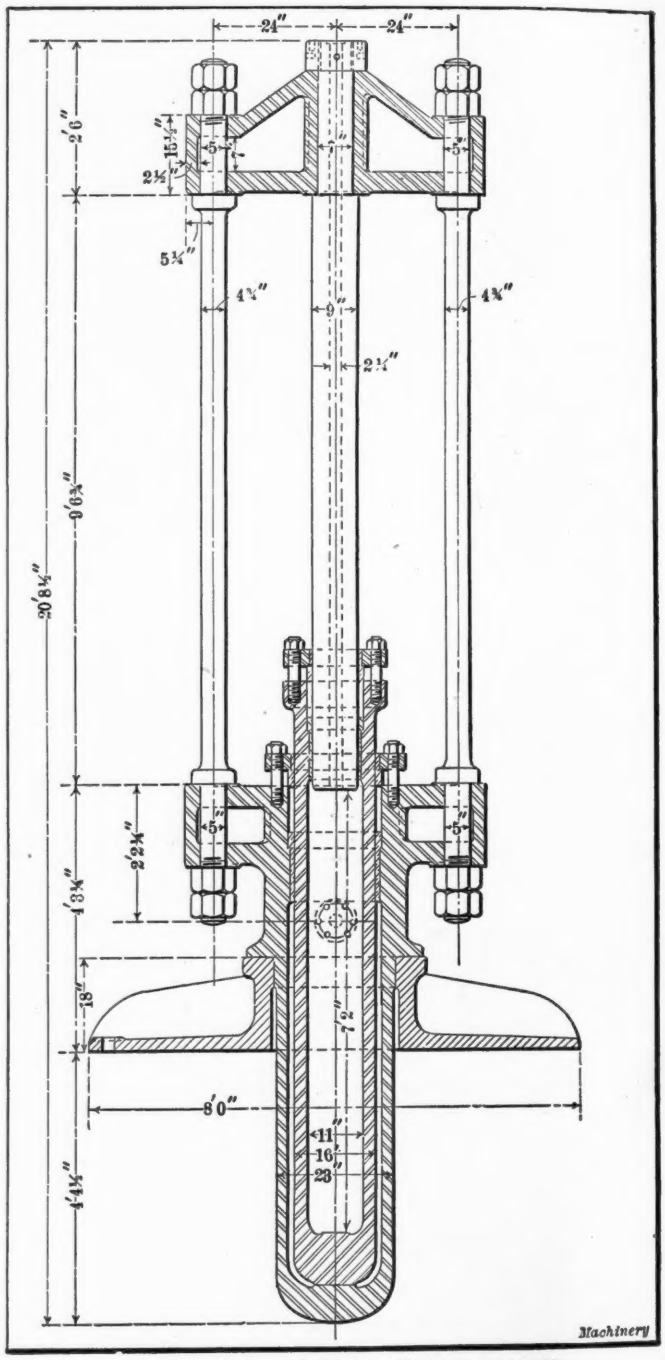

Fig. 1. General Assembly View of Hydraulic Intensifier

Therefore, the thickness of the cylinder wall is:

$$\frac{22.375 - 18.5}{2} = 1\ 15/16 \text{ inch.}$$

Using Peterson's formula as a check on the above calculations, we have:

$$t = \frac{p\,r}{S - 2/3\,p}$$

in which t represents the required thickness; p, the internal pressure in pounds per square inch; r, the internal radius of the cylinder in inches; and S, the working unit tensile stress in pounds per square inch. Therefore:

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$$t = \frac{1500 \times 9.25}{8000 - 2/3 \times 1500} = 1.98, \text{ say 2 inches.}$$

These results are in close agreement with each other. Owing to the fact that the water under pressure percolates somewhat into the pores of the casting, thereby reducing the actual effective thickness of the cylinder walls to resist the pressure, and because of the difficulties that may arise when casting the cylinder if its walls are made too thin, it is advisable to make the thickness of the walls slightly in excess of the calculated value. Another reason for increasing the thickness of the walls is on account of the fact that the cylinder will be subjected to a test pressure double the normal working pressure, while the maximum tangential unit stress S should not exceed, under the test, 15,000 pounds per square inch.

Substituting these new values in Peterson's formula:

$$t = \frac{3000 \times 9.25}{15{,}000 - \frac{2 \times 3000}{3}} = 2.135, \text{ say } 2\tfrac{1}{4} \text{ inches,}$$

which makes the outside diameter of the cylinder 23 inches.

The outside diameter of the movable ram is fixed at 16 inches, and from Fig. 1 it can be seen that the inside diameter is made 11 inches. This ram is subjected to an internal pressure of 4500 pounds per square inch, and also to an external pressure of 1500 pounds per square inch. We may, therefore, assume for simplicity that the actual pressure is the difference between the two, and since the thickness is fixed, we can determine the value of the tangential unit stress S acting upon the inner surface of the bore.

From Lamé's formula we have:

$$S = \frac{(D^2 + d^2)\, P}{D^2 - d^2}$$

$$S = \frac{(16^2 + 11^2)\ (4500 - 1500)}{16^2 - 11^2} = 8377, \text{ say 8400 pounds per}$$

square inch, which is a safe stress.

The test pressure will be applied simultaneously to the inner and outer surfaces of the ram. The tangential unit stress S then becomes, according to Lamé's formula, 16,750 pounds per square inch, exceeding the maximum value previously fixed. Strictly speaking, however, these stresses are the apparent tangential unit stresses acting at the inner surface of the bore. If we take into account the longitudinal elongation of the cylinder, the true tangential unit stress T, upon the inner surface of the bore, is found by the following formula:

$$T = \frac{(r_1^2 + 4\, r_2^2)\, p_1 - 6\, r_2^2\, p_2}{3\, (r_2^2 - r_1^2)} \qquad (1)$$

in which r_1 and r_2 are the inner and outer radii of the ram, respectively; and p_1 and p_2, the corresponding inner and outer pressures. Substituting the known values in this formula, we have:

$$T = \frac{(30.25 + 4 \times 64)\ 4500 - 6 \times 64 \times 1500}{3\ (64 - 30.25)} = 7030 \text{ pounds}$$

per square inch.

When the test pressures are applied, the values of p_1 and p_2 become 9000 pounds and 3000 pounds per square inch, respectively, and the corresponding value of T found by Formula (1) is about 14,060 pounds per square inch, which is well within the maximum value assigned for S.

A possible, but not probable, contingency may arise when the movable ram is subjected to the full internal pressure of 4500 pounds per square inch, while the external pressure is zero. In this case the value of S as obtained from Lamé's formula is:

$$S = \frac{(256 + 121)\ 4500}{256 - 121} = 12{,}565 \text{ pounds per square inch, which}$$

is a safe stress.

The total pressure acting on the small or stationary ram is $63.62 \times 4500 = 286{,}300$ pounds, nearly. Let us assume that this load is carried by two tie-rods placed as shown in Fig. 1. Let A represent the area at the root of the thread of one of the tie-rods, and assume the working unit tensile stress to be 10,000 pounds per square inch for mild steel. Then:

$$2\, A \times 10{,}000 = 286{,}300, \text{ whence } A = \frac{286{,}300}{2 \times 10{,}000} = 14.32 \text{ square}$$

inches.

From a table of bolts it is seen that the diameter of bolt having the area at the root of its threads next larger in value to 14.32 square inches is a 5-inch bolt. We, therefore, make the diameter of that portion of the tie-rod that fits in the casting 5 inches. Since the diameter at the root of thread is 4.48 inches, we will make the diameter of the body of the tie-rod 4¾ inches.

The next step is to design the top casting. This piece is a simple beam carrying a concentrated load at the center. It is a rather difficult matter to calculate the required dimensions directly from the formula, and consequently we will assume the most suitable dimensions and check them for strength. For a simple beam with a concentrated load at the center of the span the maximum bending moment occurs at the point of application of the load, and its value is:

$$M = Pl \div 4$$

in which M represents the bending moment, P the load, and l the length of the span.

The load P equals 286,300 pounds, or 143.15 tons; the length of the span is 48 inches. Consequently

$$M = \frac{143.15 \times 48}{4} = 1718 \text{ ton-inches.}$$

The unit tensile stress acting on the outer fiber at the center of the beam is found by the formula:

$$\frac{M}{S} = \frac{I}{c}$$

in which M represents the bending moment found above; I, the rectangular moment of inertia of this section; and c the distance from the neutral axis to the outer fiber. The cross-section of the top casting at the center is as shown in Fig. 2, which is equivalent, as far as the rectangular moment of inertia is concerned, to that shown in Fig. 3. The moment of inertia about the neutral axis A-A is:

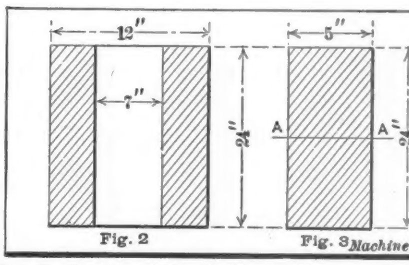

Fig. 2. Section of Top Casting at Center. Fig. 3. Equivalent Section of Top Casting

$$I = \frac{5 \times 24^3}{12} = 5760, \text{ and } c = 12 \text{ inches.}$$

$$\text{Hence, } S = \frac{1718 \times 12}{5760} = 3.58 \text{ tons per square inch,}$$

which for a steel casting is well within the limits of safety. When the test load is applied, this unit stress becomes equal to about 14,200 pounds per square inch, which is also well within the maximum value previously fixed.

The ends of the casting are in shear, the value of which is $286{,}300 \div 2$ pounds. The area resisting this shearing stress is 81.75 square inches. Hence the shearing unit stress is:

$286{,}300 \div (2 \times 81.75) = 1750$ pounds per square inch, about.

Practical considerations, in addition to the stresses produced by the external forces, were the controlling factors in proportioning this piece.

The next step is to check the studs that compress the glands. We will assume the extreme case of the glands being subjected to the full pressure on their lower surface. For the low-pressure gland, the total pressure acting on its lower surface is about 42,500 pounds. This load is borne by ten 2-inch studs. The area at the root of the thread of a 2-inch bolt having 6 threads per inch is approximately 2.5 square inches, thus giving a working unit stress of about 1700 pounds per square inch. This is a very low value, but it must be borne in mind that the gland may be unevenly

screwed down, due to the comparatively large diameter of the bolt circle, thus inducing greater stresses in some bolts than in others.

The total pressure acting on the lower surface of the high-pressure gland is about 74,200 pounds. This load is carried by eight 2-inch studs having 6 threads per inch, and consequently the working unit stress is about 3700 pounds per square inch. Owing to the fact that the bolt circle is smaller in diameter than in the previous case, the danger of an unevenly screwed down gland is not so great, and for that reason we are stressing these bolts twice as much as those in the low-pressure gland.

* * *

BAR TURNER FOR "LIBBY" TURRET LATHE

A box-type of turning tool having some interesting mechanical features embodied in its construction is shown in Figs. 1 and 2. This turning tool is used on the "Libby" turret lathe, manufactured by the International Machine Tool Co., Indianapolis, Ind., and is used for turning bar stock. It has a capacity for turning bars from ¾ inch up to and including 3¼ inches in diameter. It is clamped by four bolts to the face of the turret, the boss or shoulder *A*, Fig. 2, fitting in the bored hole in the turret, and thus aligning the tool. It carries a single high-speed turning tool *B* of 1 by ⅝ inch section. A cut 1 inch deep—the full width of the tool—can be taken in machine steel without any perceptible chatter.

The main frame or body *C* is a steel casting, cored to clear the largest bar—3¼ inches—and provided with openings to allow the chips to drop out. The front face of the frame is machined to receive two blocks *D* which carry the hardened and ground roller supports *E*, the latter being free to rotate on hardened and ground studs held in the blocks. These blocks *D* are provided with T-bases which fit in corresponding grooves in the frame and in the two blocks *F*, the latter being held to the frame by two bolts as shown. The roller supports are adjusted by collar screws *G*, which are screwed

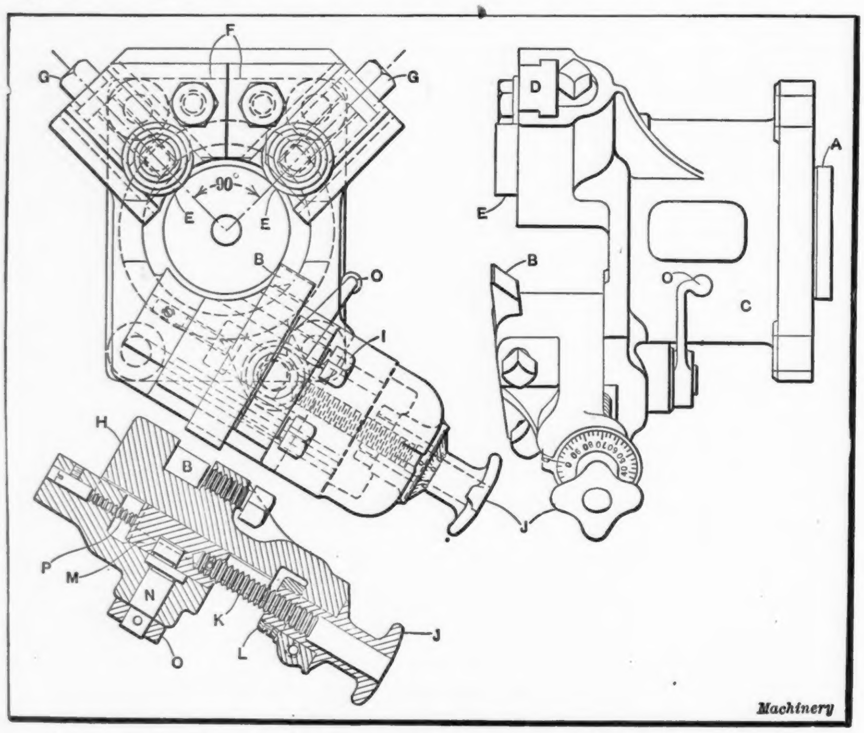

Fig. 2. Construction of the Bar Turner shown in Fig. 1, showing how the Turning Tool is withdrawn from the Work when retreating

into the frame, the collar fitting in a slot cut in the base of the block. The studs on which rollers *E* rotate are provided with oil grooves and proper means for lubrication.

The tool-slide *H* fits over a dovetailed guide machined on the front face of the frame, and is provided with an adjustable gib. A groove is cut in the tool-slide to receive the turning tool *B*, the latter being clamped rigidly in position by two set-screws. The 2½-inch adjustment of the slide *H* for the diameter of the work is effected by means of a knob *J* and screw *K*. The knob is provided with a collar having 100 graduations, and as screw *K* has 10 threads per inch, each graduation equals a movement of the slide *H* of 0.001 inch. The overhanging arm of the slide is bored to receive the reduced end of the knob and is split and provided with an adjusting screw to compensate for wear. A collar *L* screwed onto the end of the knob and locked by a headless screw is used to take up the end play resulting from the frequent adjusting and the thrust of the tool.

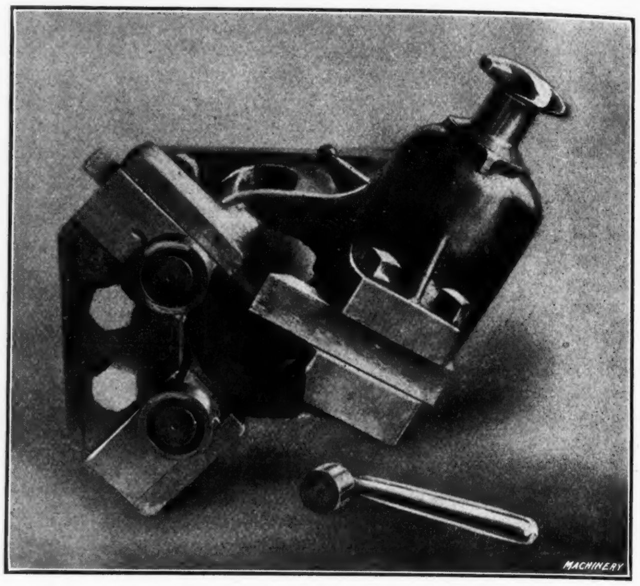

Fig. 1. Box-type of Turning Tool for the "Libby" Turret Lathe

The ordinary box-tool commonly used on turret lathes and screw machines is drawn straight back over the work after taking a cut; consequently, if a heavy cut has been taken—causing the tool to spring away from the work—the tool will make a spiral mark when returning. This objectionable feature is obviated in the particular tool illustrated in an interesting manner. The forward end of screw *K* is pinned to a block *M* which fits in a slot cut in the frame *C*. This block is actuated by an eccentric stud *N*, the latter being operated by a handle *O* held on it by a pin. When the cut has been finished, the operator pulls out handle *O*, rotating the eccentric, which, in turn, withdraws block *M* from stop *P*. Then as screw *K* is fastened to block *M*, thus connecting it with slide *H*, it follows that the slide carrying the turning tool must also recede. When handle *O* is pushed in, block *M* is located in the exact position by stop-screw *P*, which is locked with a headless screw, thus setting the turning tool again to the correct diameter.

Another commendable feature in the construction of this tool is the location of the turning tool relative to the supports and the body of the holder. The turning tool is set tangentially to the work and is also so placed that it can be located in advance of the supports or face of the holder. This construction allows the tool to cut close to a large shoulder—much larger than the width of the frame—without any portion of the holder coming in contact with the work. This feature makes this turret tool especially valuable for turning large work. The wrench shown in the foreground in Fig. 1 is used for tightening the set-screws on the turning tool.

D. T. H.

* * *

On January 1, 1912, there were 70,000 power driven vehicles in use in Germany, about 63,000 of which were passenger cars and about 7000 trucks. Of the passenger cars about 23,000 were private pleasure cars and 30,000 were used for business purposes. There were also 5200 motor cabs and omnibuses in use.

MUSEUMS OF SAFETY AND THEIR ACTIVITIES*

A BRIEF HISTORY OF THE MOVEMENT FOR THE PREVENTION OF INDUSTRIAL ACCIDENTS

BY MANCIUS S. HUTTON†‡

It is not so many years ago that labor was considered one of the cheapest of commodities and the employer of labor simply hired a new man in place of one incapacitated through injury at his work. He did not take the time to study how accidents could be prevented, nor did he spend money in placing safeguards about the works; but he was willing to spend the same or more money in fighting, in the courts, the claims for damages which the injured employe tried to obtain. The old common law liability of employers was very lenient at first towards the firms in whose shops accidents happened, but latterly the juries have been awarding larger sums to the sufferer. Within the last four years, however, the relations between the employer and his workmen have been changing in many places by the former's recognition of his responsibility for his work people, and he has been trying to safeguard the dangerous places around his factory. He has also been forced somewhat to do this by the casualty insurance companies in order to obtain a lower premium from these companies.

Present Activity in Passing Laws to safeguard the Industrial Worker

In nearly all the states, at the present time, laws in regard to safeguards have been made more stringent. In some of the states, commissions have been appointed to investigate and report to the legislature on the whole question of accident and sickness prevention, with the object of enacting laws which would tend to reduce the number of industrial accidents by compelling the introduction and use of safeguards. These laws, however, should not be made so exacting as to bankrupt the small employer.

When enacting workmen's compensation laws in the various states, which in no case were made compulsory, the law makers so changed the common liability law that it became to the advantage of the employer to accept the terms of the compensation law rather than to go to the courts under the liability law. This was done by taking away from the law the two defences under which the employer had the best chance of winning the suit. These defences are known as the "assumption of risk" and the "fellow servant rule." The former of these is that an employe who contracts to work for an employer assumes the hazard of the occupation. The latter one is that an employer cannot be held responsible for an injury to the workman which was caused by another employe engaged in the same work.

The recognition on the part of the employer of his responsibility toward his work people, the passing of more stringent factory laws, and the enacting of compensation laws, all have brought the employer to the realization that the question of safety and sanitation in his factory is a very vital one. He is now, therefore, studying these questions and others which are related to them. It is obvious that it would be to the employer's advantage to find all the material and information on safety devices brought together in one place for study. This is the genesis of the idea of museums of safety.

Foreign Museums of Safety

The first museum of safety was opened to the public at Amsterdam, Holland, in 1893. This museum, at the start, was a very small affair and was entirely supported by private subscriptions, but it soon outgrew its first quarters. In 1910 the city gave a site for a new and larger building, while the parliament appropriated $22,500 for the building. The running expenses will, as hitherto, be borne by private subscriptions. This museum was opened eight years before the country passed a workmen's compensation law.

There are at present sixteen museums of safety, of which fourteen are in Europe, one in the United States, and one in Canada. In the following table is given the location of these, together with the year of their opening and the year in which the compensation law in that country was first enacted.

City	Country	Year of Museum Opening	Year of Enactment of Compensation Law
Amsterdam	Netherlands	1893	1901
Berlin	Germany	1903	1884
Budapest	Hungary	1908	1907
Copenhagen	Denmark	1910	1898
Dresden	Germany	1911	1884
Gratz	Austria	1911	1887
Helsingfors	Finland	1910	1895
Milan	Italy	1906	1898
Montreal	Canada	1909	1909
Moscow	Russia	1908	1903
Munich	Germany	1906	1884
New York	United States	1907	1906
Paris	France	1905	1898
Stockholm	Sweden	1908	1901
Vienna	Austria	1909	1887
Zürich	Switzerland	1902	has none

The year given for the New York museum is that of the first exhibition of safety devices. It was not until three years later that a permanent museum was opened. The year given in the fourth column is that of the first Federal Compensation Law in the United States.

The following countries which have passed compensation laws have no public museum of safety:

Country	Year of Enactment of Compensation Law
Norway	1894
Spain	1900
Belgium	1903
Great Britain	1907

From the table it will be seen that Germany has three museums at the present time and Austria two. It is an interesting commentary on this movement that while Switzerland has never passed a compensation law, yet it was the second country to have a public museum of safety and sanitation located at Zürich; and Germany, which was the first country to have such a law, did not open its first museum at Berlin until nineteen years after the law went into effect. This latter museum is one of the largest and most up-to-date in the world. Its actual location is at Charlottenburg, a suburb of the city. The building occupies one-sixth of an acre and contains, besides the exhibition hall, the administration offices and a lecture hall which can accommodate two hundred people. The exhibition hall covers an area of 64,000 square feet.

In the summer of 1911 there was held in Dresden the first International Exhibition of Hygiene. This exhibition was opened to the public in April and closed in October. From the time of its opening to the first of September it has been estimated that four million people visited it. Nearly every country was represented, even those of South America, by either a pavilion or a section in a building. The United States was the only large country which was not officially represented. It was an educational campaign put in practical form by means of models and charts, so that the lesson could be easily understood and would not easily be forgotten. The preparations for the exhibition required over four years. After it had been closed there was a popular demand on the part of the German people that the models and charts which had taken so long and so much painstaking care to prepare should not be destroyed, but should be kept in a museum. Thus it was that Dresden's name was added to those cities which have a permanent museum.

One reason why the German museums are ahead of others in regard to their buildings and exhibits is the encouragement and financial backing which the government gives them. In the case of all the foreign museums, with the exception of that in Vienna, the government or the city in which they are located have given some financial help. Some of the foreign

* The following articles on this and kindred subjects have previously been published in MACHINERY: "American Museum of Safety Award of Medals," February, 1912; "The Prevention of Industrial Accidents," November, 1911, engineering edition, and the articles there referred to.

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museums occupy only part of a building, as is the case of the one in Paris, which is located in the Vaucasson Gallery of the National Conservatory of Arts and Trades.

To the average American these foreign museums are of no practical benefit, as few can visit them and the literature which they publish is not within the reach of everyone unless translated. The reason for mentioning them has been to show the large number located in the principal centers of Europe.

The American Museum of Safety

The idea of having a museum of safety devices in America was conceived by the present director of the Museum in 1900, on his return from abroad where he had seen, in Paris, a partial exhibit from the Amsterdam museum. The next seven years were spent in educational work by means of lectures throughout nearly all the states. The next step forward was the holding of an International Exhibition of Safety Devices in New York City which lasted two weeks. This was held at the Museum of Natural History in February, 1907. It exhibited practical safeguards in the way of models, photographs and actual devices manufactured by American firms; it also had actual devices, photographs and charts of methods which were in use abroad. These latter were obtained from the foreign museums. After this exhibit was over it was decided to hold another the next year, which should be open for a longer period. The exhibition of 1908 was held at 231-241 West 39th St., New York City, and extended over a period of two months (April-May); it contained exhibits from eighty different American firms, while the foreign museums were again represented by documents, photographs and charts. There were only a few models of foreign devices shown at this exhibition. The next year was spent in lecture work and in visiting factories in which safety devices were being used. In November, 1910, the first permanent Museum of Safety and Sanitation in America opened its doors and invited the public to come and visit it. It is located on the sixth floor of the United Engineering Building, 29 West 39th St., New York City, and occupies two rooms. It is open every day, except Sundays and holidays, between the hours of 9 A. M. and 5 P. M.

There are four methods in which a museum of this kind can have its work brought to the attention of the public:

1. By the collecting and displaying in a museum of the actual safety devices themselves, or, if too large or cumbersome, of models of them. The devices should be constructed so that they can be operated in the same way as in actual practice. If either the device or model cannot be shown, then the device should be illustrated by photographs, blueprints or charts.
2. By the assembling of a library of all the literature pertaining to the subjects which have to do with the question of improving the workmen's condition. The library should be fully catalogued and contain foreign books and pamphlets as well as American literature.
3. By means of lectures illustrated with lantern slides of the best safety devices. These lectures are delivered at the principal industrial centers and before employers, workmen, societies, associations, state and city officials, and others interested.
4. By the publication of literature on various subjects relating to the workmen's welfare, such as illustrated books, pamphlets and leaflets; besides promoting the movement through articles published in the daily papers and the technical press; and the making of special reports and publishing of same.

The first and second methods are by far the most advantageous as regards the studying of safety devices and industrial hygiene, but they are limited to those persons who live in or near the city in which the museum is located. Those outside this narrow area would not gain any advantage from it. The third method has a larger scope, but is limited by the fact that it is only possible to lecture a limited number of times in any year in any one large industrial center. The publication of illustrated books, pamphlets and leaflets which can be mailed to anyone, places the last method far ahead, as regards the number of persons which it reaches, of all the other methods combined.

It may be of interest to those not familiar with the service which such a museum can render, to make some extended references to the activities of the American Museum of Safety. It applies all four methods given above. In its exhibition hall it now has over two hundred full-sized apparatus and models, besides having at least three thousand mounted photographs from both foreign and American practice. The exhibits, including the photographs, are divided into three sections, each of which is under the jurisdiction of a committee; more sections will be added from time to time, as space and exhibits warrant. The three sections at present are: iron and steel; fire prevention; and industrial hygiene and sanitation. There is also a general section which includes exhibits which do not come properly under the other three. The chairmen of these section committees are men who are authorities on their special subject.

The exhibits are put in the museum by the manufacturer or inventor himself. Among the conditions for exhibiting are the following:

1. No exhibit is allowed to be displayed which has not been approved of by the Board of Approval of Exhibits.
2. There will be no charge for space in the exhibit hall.
3. The installation of an exhibit is at the exhibitor's expense.
4. Exhibits are accepted with the understanding that they are not to be removed within twelve months except with the consent of both the Director and the Chairman of the Board of Approval.
5. Exhibits are not accepted which are not purchasable in any market or commercially available in the industries as a means to prevent accidents.
6. Untried inventions are not accepted.
7. The museum assumes no responsibility for any damage by fire or loss by theft.

These conditions are nearly the same in all the museums.

A few of the more important firms which are exhibiting in this museum at the present time are: The United States Steel Corporation, and several independent steel companies, Brown & Sharpe Mfg. Co., Mergenthaler Linotype Co., National Cash Register Co., Norton Co., Patent Scaffolding Co., Pennsylvania Railroad Co., Prudential Insurance Co., Standard Oil Co., Travelers Insurance Co. and many others.

The American Museum has been visited since its opening by the presidents, general managers and committees of safety of different companies, state factory inspectors, casualty insurance inspectors, engineers, workmen and students. The museum provides a demonstrator who shows and explains all the devices.

The library of the museum contains bulletins, reports, catalogues, books, charts and articles taken from different publications. When this library was started there was very little literature on these subjects in the English language, while the foreign publications were more numerous, especially those in German. Accident prevention is now a very live subject in America, the result of which is that special articles and books are increasing in numbers. Many of the foreign publications are not easily obtainable anywhere else in the United States for reference or study. This library is growing very fast and is an important adjunct to the museum.

In lecturing before associations, workmen, superintendents, foremen, inspectors and others, the museum has had a splendid chance to do educational work. At the present time there are four members of the museum who are doing this lecture work. Each of them has from one to two hundred colored slides of practical safety devices. During the last year the director of the museum has had the opportunity of lecturing before the superintendents, foremen, and workmen of several of the large steel companies, the New Jersey Zinc Co. and the Pennsylvania Railroad Co. The number of people who have been reached by these lectures averaged between three to twenty-one hundred at each lecture. The total number of lectures delivered during the year has been in the neighborhood of fifty.

From the time of the museum's first inception to the present time, there have been published a number of pamphlets and books to promote the work of the museum, as well as to educate the public to the waste of life in the industries. The museum has had the cordial cooperation of the daily papers and the technical press in the work which it is carrying on. The museum, at the present time, is engaged in publishing

"Safety Manuals" and leaflets, of which two manuals and three leaflets have already been published. Other manuals and leaflets are in preparation and will be issued from time to time during the course of the year. The museum has embarked on a new method of valuable help to the employer which is the inspection of plants and the reporting of the kind of safeguards recommended. The museum is always glad to answer any legitimate question in regard to accident prevention.

The museum awards annually three gold medals, the first of which is known as the "Scientific American Medal of the American Museum of Safety," and is given to "such individual or corporation as has produced and exhibited in the American Museum of Safety within a recent period of years any perfected device of utility which in the judgment of the Jury of Award of said museum best conserves human life and limb in the processes of productive industry." This medal has been awarded three times. The second medal is the "Travelers Insurance Company Medal of the American Museum of Safety," which is awarded to the "American employer or other corporation which in the judgment of the Jury of Awards of the museum has done most or achieved greatly, during a recent period of years, in the conservation of the lives and limbs of their workmen by means of safety devices for machines and processes." This medal has been awarded twice. The last medal is the Louis Livingston Seaman Medal of the museum to be given for progress and achievement in the promotion of hygiene and sanitation and the mitigation of the evils of occupational disease. This was awarded for the first time in 1911.

The Legislature of the State of New York passed in May, 1911, a bill incorporating the American Museum of Safety. The museum is a non-commercial enterprise, and it does not take orders for any of the devices it happens to exhibit. It has so far received no financial support from city, state or national government, but is maintained entirely through membership subscriptions. In this respect it differs from the foreign museums, which, as explained before, obtain at least some governmental support. It is to be hoped that the industrial community will realize the public service which the museum is rendering and will seek to cooperate in its work as a public duty.

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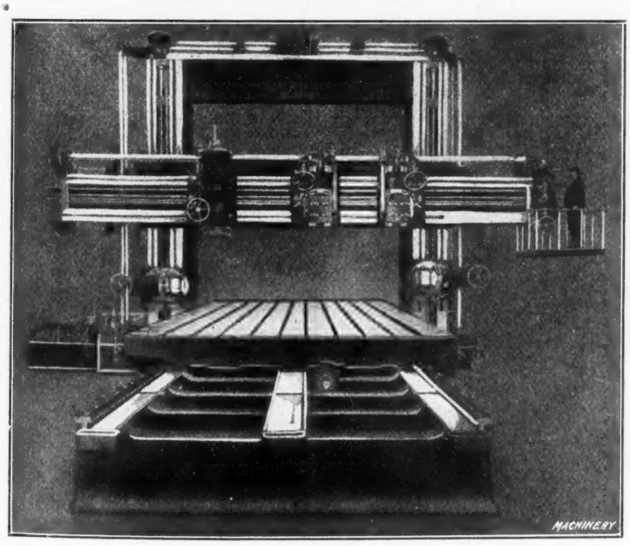
A LARGE GERMAN PLANER

The accompanying illustration shows a planer built by the firm of Wagner & Co., Dortmund, Germany. This machine is intended for work on turbine housings and is built for F. Schichau in Elbing. The extreme length of work that can be



A Large Planer which takes in Work approximately 34 by 16 by 13 feet

done is about 34 feet 5 inches, and the extreme width, 16 feet 5 inches, the limit in height being 13 feet 1 inch. The main drive is from a 60-horsepower motor. The machine is provided with a milling head in addition to the four planer heads. Auxiliary motors are used for the various feeds.

PLANING STEEL RACKS FOR FROG AND SWITCH PLANERS

The rack used on the frog and switch planers manufactured by the Cincinnati Planer Co., Cincinnati, Ohio, is made of a steel forging instead of from cast iron, on account of the heavy duty that this type of planer is called upon to perform. The rack is made in sections, these being fastened securely by bolts and dowels to the under side of the planer table. To cut the rack teeth, the sections of the rack are clamped to the planer table, as shown in Fig. 1, the rack teeth being formed with cutting tools held in the tool-head.

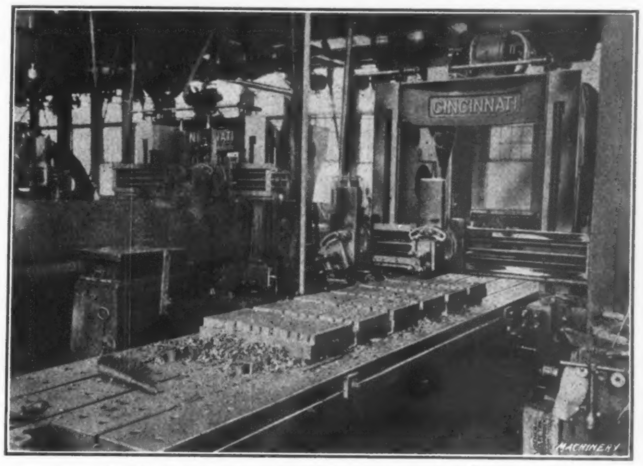


Fig. 1. Planing Teeth in Steel Racks for Frog and Switch Planers

The rack sections shown clamped to the planer table in Fig. 1 are made from 40-point carbon steel forgings, and the teeth, which are 1½ diametral pitch, are cut from the solid block. Naturally, this operation requires considerable time, and calls for a special type of planer tool equipment. The successive tools used are shown in Fig. 2. Here *A* is the first roughing tool—similar in shape to a wide parting tool—with a nose ⅝ inch wide. This tool is used to rough out the teeth, taking a cut 0.040 inch deep per stroke, at a cutting speed of 40 feet per minute. After all of the teeth have been roughed out to within about ⅛ inch of the proper depth, tool *B*, having a stepped face is used to rough out the angular

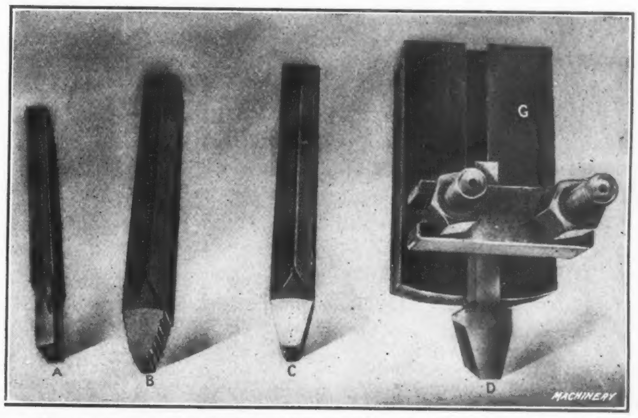


Fig. 2. Successive Tools used in Cutting the Steel Rack Teeth in the Rack for a Cincinnati Frog and Switch Planer

sides of the teeth. Next, tool *C* is put in the tool-holder, and all the teeth are finished to within about 1/64 inch of the proper depth.

The final shape is given to the teeth by the rack-tooth cutter *D*. This is held by a strap, bolts and nuts in a slot in the special block *G*, the latter fitting snugly in the clapper-box. Holding the finishing tool in this manner insures that the teeth will be accurately formed on the sides, and also maintains the proper face angle. The spacing of the teeth, of course, is accomplished by means of the micrometer collar on the rail-screw.

D. T. H.

* * *

The total steam power used in the United States is about 27,000,000 horsepower. It is estimated that 35,000,000 horsepower could be made available from the waterfalls. Of this about 5,000,000 horsepower has been developed.

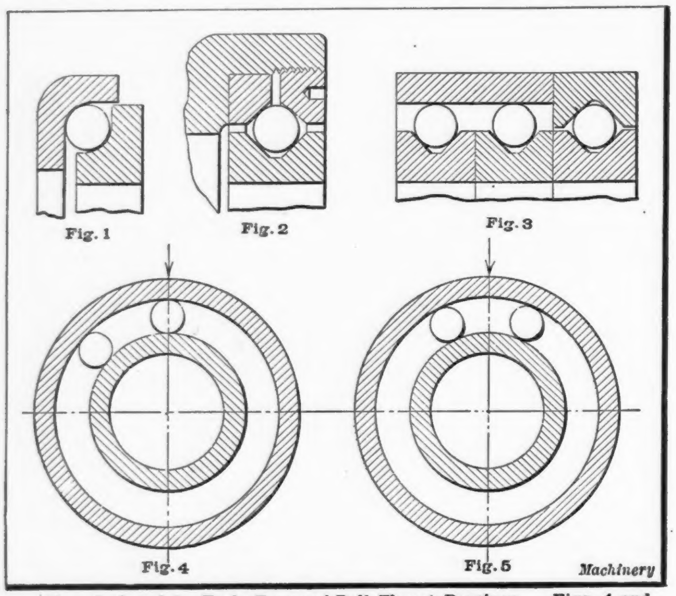
BALL AND ROLLER JOURNAL BEARINGS*

THEIR DEVELOPMENT FROM EARLY TYPES AND CONSIDERATIONS IN THEIR DESIGN

BY ROBERT H. GRANT†

In a previous article, appearing in the August number of MACHINERY, the writer reviewed the history and development of ball and roller thrust bearings. In this article ball and roller journal bearings will be treated.

The first type of ball bearing used was that known as the cup and cone type, a section of which is shown in Fig. 1. The design of these bearings has been varied considerably, some designers having advocated a two-point bearing, and others a three-point bearing; some have believed in the use of large balls, and others in balls of a smaller size, etc. At the present time it is of little importance, however, as later types of bearings have taken its place.



Figs. 1, 2 and 3. Early Types of Ball Thrust Bearings. Figs. 4 and 5. Action of Ball Journal Bearings when Distance between Bearing Points is too Great

The next type of bearing was the grooved ball shaft bearing, a section of which is shown in Fig. 2. This bearing had three hardened steel races, and was fitted to a housing or hub. The plain outer race was driven into place and the threaded race was a good fit in the housing, so that the two would be in alignment with each other. The inner race or cone was a sliding fit on the shaft, so as to allow it to adjust itself to the outer races. This bearing was satisfactory for light loads and high speeds, but had to be very accurately ground and fitted; otherwise there would be a three-point bearing instead of a four-point, which would soon cause wear. On account of the expense of manufacture and mounting, this bearing has been very little used. The adjustable feature also caused a great deal of trouble due to the fact that inexperienced users would adjust the bearings improperly; hence, types were developed in the early years of bicycle manufacture which could not be adjusted.

The next bearing developed was a modification of the grooved ball shaft bearing, as shown in Fig. 3. The first bearing in the series is a regular grooved ball thrust bearing which takes the end thrust, while the other ball bearings take the journal load, thus distributing it over the whole length of the journal bearing. This bearing was applied to a railway car as early as 1888 and is now quite extensively used on electric cars.

While many other bearings have been developed and tried, the regular annular ball bearing has been adopted by nearly all manufacturers as the standard. These bearings are now being made of the same inside and outside diameters and thicknesses by all makers. The various makes differ only in the material, workmanship, size of ball, and design of cage. The material mostly used for the ball races is an alloy steel made in the form of tubing. One steel much used for this purpose, as made by the Becker Steel Co., of New York, is composed of carbon, 1 per cent; chromium, 1.25 per cent; manganese, 0.35 per cent; phosphorus and sulphur, not to exceed 0.025 per cent; and silicon, 0.25 per cent. In German bearings a chromium content between 1.50 to 1.60 per cent is used. It is claimed that this alloy steel gives still better results. Alloy steels of this type will stand a high surface pressure, which is necessary on account of the fact that the ball has practically only a point bearing in the race.

The cage, the design of which varies considerably with different manufacturers, should be made of a light, strong material and should prevent the balls from coming in contact with each other, and at the same time give them perfect freedom of action. The diameter of the balls to be used must, of course, be determined largely by the load that is to be carried; the ball must have sufficient diameter to stand the strain. It is evident that the closer the points of contact are to each other when the load comes onto the balls, the better will the bearing run. If the balls are small there will be a greater number of points of contact, and the bearing will work more freely, but the size of the ball must be kept within safe limits to prevent it from breaking.

The ball cage is of vital importance, as it reduces the friction between the balls, preventing them from rubbing against each other, but it should be so made that the bearings can be almost entirely filled with balls. In Figs. 4 and 5 are shown two diagrammatical sketches to illustrate the importance of having the bearing nearly filled with balls and the bearing points as close to each other as possible. When the load is directly over one ball, as shown in Fig. 4, this ball will carry the greater part of the load. When the load comes between the balls, as in Fig. 5, the ball just coming into action will necessarily take more of the load than the ball which is leaving the line of action. It will carry this increased load until it reaches the center and for some distance beyond. Thus it can be seen that if three or four balls are at the same time near the line of action, the load of the bearing is more evenly distributed over the balls. This condition can only be obtained by making the cage so that the balls practically fill the annular space of the bearing.

Types of Ball Bearing Cages

The first cages used were designed with so great a distance between the balls that the bearing could carry only a very light load. In recent constructions it has been found possible to make ball bearings with a cage where 96 per cent of the space between the races is filled with the balls. The balls are introduced through filling slots, the size of which is a little less than the diameter of the ball, so that the latter are forced in between the two races under pressure. The shallow filling slots are not as deep as the ball races and are inclined at an angle to these. The early cages, such as shown in Fig. 6, were made from brass castings and were very clumsy and heavy. Later sheet-steel cages came into use, but the best cages, at the present time, are pressed up from sheet bronze or brass, in two parts, and are then riveted or fastened together after the bearing has been assembled.

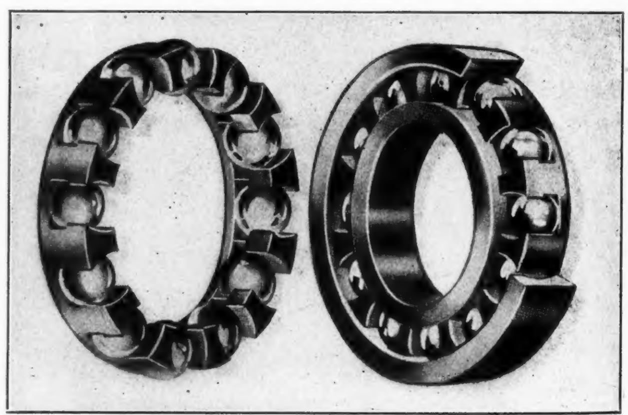
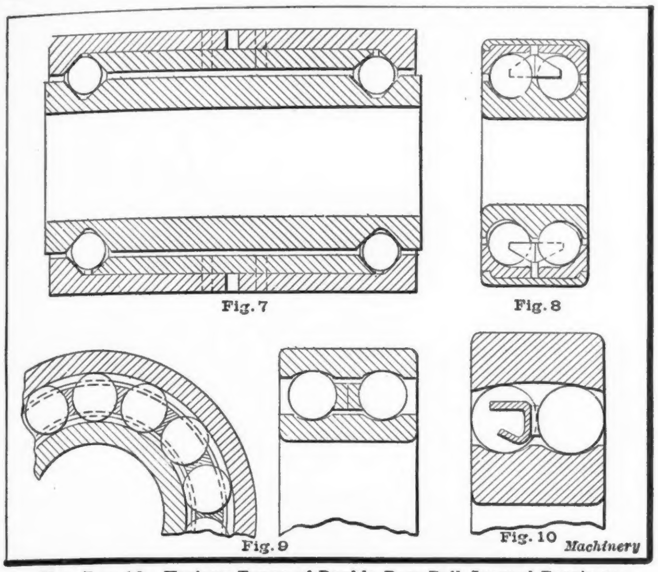


Fig. 6. Early Type of Ball Cage for Journal Bearings

*See "Ball and Roller Thrust Bearings," MACHINERY, August, 1912.
†Address: 912 Oakland Ave., Ann Arbor, Mich.

Double Row Annular Bearings

On account of the thrust to which annular bearings are sometimes subjected, the regular type was found unsatisfactory for certain work, and the double-row annular bearing was introduced. The first double-row annular bearing made in this country was designed and put on the market by the writer in 1890. The first design of this bearing is shown in Fig. 7. This bearing was not ground, but simply polished, and proved very satisfactory in a great many cases. It was, however, somewhat ahead of its time, and did not become as popular as the single-row bearing. The first double-row bearings of this type were made from soft steel and casehardened. Later they were made from regular tool steel and finally from an alloy steel.



Figs. 7 to 10. Various Types of Double Row Ball Journal Bearings

A type of double-row annular bearing made by the New Departure Mfg. Co., Bristol, Conn., is shown in Fig. 8. This bearing is composed of a cone with two grooves, two cups, and a shell. One cup is first forced into the shell, then the bearing is assembled and the second cup forced into place, after which the shell is spun over at the ends. When this bearing was first made, the cage was solid, and, therefore, caused considerable trouble, as it was practically impossible to get both races of exactly the same diameter. This caused the balls on one side to run at a different speed from those on the other, resulting in damage to the cage. This difficulty was overcome by making the separator in two parts, thus allowing each row of balls to run independently of the other.

Another type of double-row annular ball bearing is that brought out by Fichtel & Sachs, as illustrated in Fig. 9; this is practically composed of two single-row annular bearings. The cage used in this case is especially advantageous, as it permits the balls to occupy about 96 per cent of the annular space. The balls are introduced after the cage has been put into the bearing.

The double-row annular ball bearings manufactured by the S. K. F. Ball Bearing Co., Fig. 10, have a distinctive feature of self-alignment. Although this bearing has a retainer made of one piece, it is so constructed that both rows of balls take an equal amount of the load at all times.

Review of Manufacturing Methods

In the manufacture of annular ball bearings the methods have changed very rapidly. The bearings were first made by turning the races from a solid bar, which was a very expensive process, as about 75 per cent of the stock was wasted. In Fig. 11 is shown the method wh ch the writer adopted in the early stages of the ball bearing manufacture, in order to economize on material as well as to cheapen the cost of production. The operations were performed on a Cleveland automatic screw machine and consisted in first drilling and reaming the central hole; then, with a hollow mill having a pilot to guide it, the space between the races was cut out. A grooving tool formed the recesses for the balls, after which the pieces were cut off. As the larger sizes of bearings came into use, forgings were adopted for the races for these sizes. The method first employed for finishing these forgings was to use a hand screw machine; later the semi-automatic machine was adopted for this work.

The latest and best method for making the ball races is to make them from tubing. On account of the processes through which the tubing has passed, the metal is very dense and close grained, so that the bearings made from this material have an excellent bearing surface.

After the races have been machined it is necessary that they should be heat-treated. The treatment consists in heating the bearing very slowly to or near the recalescent point and then allowing it to cool slowly. This treatment is given to the ball races in order to prevent them from warping out of shape in the hardening process. After being hardened they are subjected to an artificial seasoning; without this operation they would not keep their shape.

The simplest method employed for the seasoning is to use a wheel about 6 feet in diameter, mounted on the top of a tank containing boiling water. The wheel is slowly revolved, and to it are attached wire baskets which hold the races. These come into contact with the boiling water for a short time, after which they cool off slowly during the remainder of the revolution of the wheel. The races are subjected to this treatment for about twelve hours, and in this way a result which ordinarily requires two months for its accomplishment is rapidly obtained.

The next operation is to rough-grind the bearing, after which it is allowed to rest for several days before being finish-ground. When finish-grinding the bearing, it is completely finished all over except on the outside diameter, which is left until after the bearing has been assembled, in order to insure perfect concentricity. The machines and methods used in the manufacture of ball bearings will be taken up in detail in a future article.

Roller Journal Bearings

In the making of roller journal bearings, the most difficult problems are to insure the alignment of rollers and to take care of the thrust at the end of the roller. Most of the improvements on these bearings have been to provide rings or collars to hold the rollers in position, as well as to take the thrust. One of the first roller bearings to be manufactured was made by the Ball Bearing Co. of Boston, Mass. This bearing had thin annular disks or washers at the ends, with flat brass stay-rods connecting them. The sides of these stay-rods were concave and held the rollers in place. The rollers were made in short lengths with nothing to prevent them from wearing out through the end of the cage, which they very often

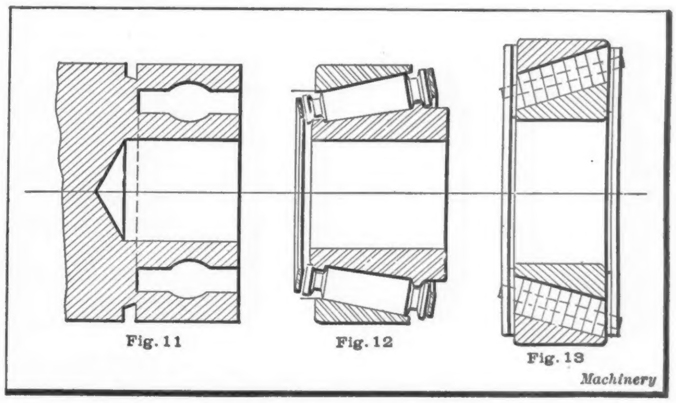


Fig. 11. Method of Turning Ball Races from Bar Stock. Figs. 12 and 13. Taper Roller Journal and Thrust Bearings

did when the sleeve, casing or roller was not ground perfectly straight.

The Standard Roller Bearing Co. of Philadelphia, Pa., then brought out another roller bearing in which the cage was made by drilling holes into the ends of sleeves, the metal in which was thinner than the diameter of the roller to be used. Two such sleeves were used for each bearing (one at each end), the two sleeves being held together by stay-rods. A ball was placed at the bottom of the drilled hole, against the end of the roller, in order to minimize the friction. This construction, of course, overcame the difficulty of having the roller wear through the cage end, but the rollers were not kept in perfect alignment, as the holes in the cages had to have some play in order to have the bearing run smoothly.

Other bearings have been developed which overcome the difficulties mentioned. Among these are the Zahn bearing where the roller is provided with a groove around it which fits either a projecting ring solidly held in the bearing, or shoulders on the races which are supposed to keep the roller in perfect alignment, and, at the same time, take the thrust. Another bearing known as the Johnson bearing, which is shown in Fig. 14, is provided to take the end thrust as well as the annular load and to overcome the difficulties due to lack of alignment in the rollers. In this bearing the stay-rods which hold the cage together are provided with two balls inserted in them which hold the rollers in alignment. The ends of the cage are grooved and a hardened steel washer is inserted. The balls which take the end thrust bear upon this washer. The roller is also provided with a ball at each end to eliminate friction. This bearing has some good features, but it is very intricate and must be made with great care. It is also rather expensive unless used where the end thrust, as well as the radial load, is to be carried.

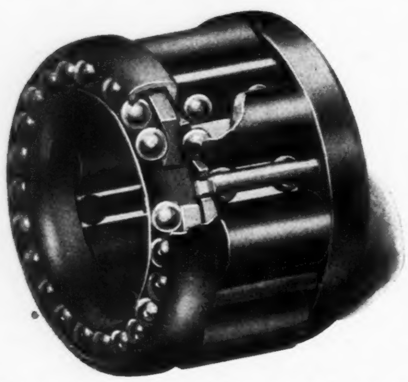


Fig. 14. The Johnson Bearing for taking Both Radial Load and End Thrust

Taper Roller Journal Bearings

Taper roller journal bearings have certain advantages, but they also introduce certain conditions which are difficult to overcome, the same as do taper roller thrust bearings. The first bearings of this kind were made by the Grant Axle & Wheel Co., of Springfield, Ohio. This bearing took the thrust on the cone and had holes in the rollers with stay-rods through them to form the cage. This style of bearing is supposed to take the thrust as well as the radial load. When taking the thrust on the ends of the roller, however, there is a tendency to twist the roller and to get it out of alignment with the axis of the shaft, and if the rollers are not all of exactly the same size, the larger rollers that take the thrust will soon chip off and wear out.

The Timkin Roller Bearing Co., of Canton, Ohio, soon followed the Grant Axle & Wheel Co. in making a bearing in which the thrust was taken exactly as in the Zahn bearing previously mentioned, where the roller is grooved and fits ridges in the race. To still further develop this bearing, two grooves were provided in the roller and two ridges on the inner ball race, as shown in Fig. 12. The latest type of straight roller taper bearing is that shown in Fig. 13. Here the rollers are made up of short straight sections, the same as in a plain roller thrust bearing. The use of straight rollers in this bearing causes slippage of the rollers. On account of the difference between the surface speed at the large and small diameters of the cone, there is a great deal of slippage which, although it increases the friction, at the same time takes the thrust of the bearing.

* * *

WORM AND HELICAL GEARS AS APPLIED TO REAR AXLE DRIVES*

European practice extending over a period of fifteen years has given ample evidence of the eminent success of the worm and helical type of gearing, and the author feels confident in saying that in the near future a large percentage of the cars in the United States will be equipped with this drive. The principal reason for the adoption of the helical form of tooth appears to be its peculiar quality of silence, regardless of speed or load. With the best methods of design and assembly, great durability, strength and efficiency are obtained.

It is impracticable in an article of this character to cover all the details satisfactorily. However, the author believes that on all styles of cars in the United States to-day the worm gear could be used successfully for rear axle purposes.

The successful worm gear should embody the following qualifications:

1. Cheapness of construction.
2. Strength for resisting shocks.
3. Hardened and smooth surfaces for durability.
4. Material of a suitable composition to reduce friction.
5. Simplicity of construction and mounting.
6. Perfect bearing conditions.
7. Noiselessness at any speed or load.
8. Reversibility.
9. Lightness in weight.
10. High efficiency in power transmission.

Granting that there is some argument against the worm in regard to trucks as to the dead axle proposition, this could be overcome by using a worm gear on each end of the axle, the same as sprocket wheels, having a double worm gear drive in place of the cumbersome chain drive. If at first slightly more expensive than the chain and sprocket drive, less repairs will more than make up the difference. Care should be taken to have accurate bearings, both radial and end-thrust.

RESULTS OF EFFICIENCY TESTS ON ORDINARY TYPE WORM-GEAR FOR AUTOMOBILE REAR AXLE DRIVE FOR ELECTRIC VEHICLES AND LIGHT POWER CARS

Number of Test	Temperature of Worm-gear, Degrees F.	Twist of Shaft in Degrees	R. P. M. of Worm	R. P. M. of Worm-gear	Input, Transmission Dynamometer, Horse-power	Output, Brake Horse-power	Efficiency, Per Cent
1	74	$1\frac{1}{4}$	1393	143	1.64	1.01	61.6
2	82	2	1423	146	2.65	2.11	79.6
3	86	$2\frac{3}{4}$	1416	145	3.41	3.11	91.3
4	86	$3\frac{9}{16}$	1416	145	4.46	4.15	93
5	90	$4\frac{7}{16}$	1370	140.5	5.48	5.03	92
6	94	$5\frac{7}{16}$	1389	142.5	6.72	6.12	91.2

Worm-gear: Phosphor-bronze, 39 teeth.
Worm: Casehardened steel worm, solid on shaft, quadruple thread.

Considerable discussion has arisen in regard to the relative merits of the straight and Hindley types of worm gearing. In my opinion both can be used successfully, although each has its own advantages and disadvantages. For most purposes, particularly where considerable power is to be transmitted, the Hindley type has the advantage, but with ordinary machinery it is somewhat more difficult to obtain the same degree of accuracy as can be obtained in the case of the straight type.

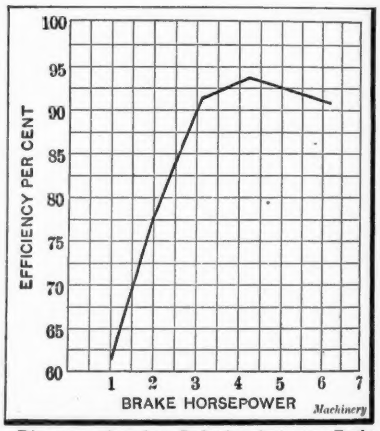


Diagram showing Relation between Brake Horsepower and Efficiency, based on Results of Tests

From tests made there is no question but that there is a larger bearing surface on the Hindley type of worm than on the straight. Therefore this type of gearing will for the same pitch present a bearing of greater durability, and heat less than the straight type, particularly under heavy load. The straight type may have less trouble with end-thrust bearings. The worm can move in its position longitudinally with the worm axis and therefore does not require as close an adjustment of the end-thrust bearings. With first-class bearings the Hindley type has the advantage, as a smaller and lighter gear can be used, thus reducing the expense.

Some efficiency tests on an ordinary type worm and worm-gear for automobile rear axle drive, for electrical vehicles and light-power cars, were undertaken by the author. A transmission dynamometer, similar in some respects to the apparatus used at the Massachusetts Institute of Technology by Prof. Riley, was constructed. The prony brake was adopted for an absorption dynamometer, and a long shaft of small diameter was arranged to obtain the torsion of the shaft in degrees by an electrical indicator apparatus for a transmission dynamometer. The results of the tests are given in the accompanying table. The diagram shown gives a curve plotted from the results obtained in the tests and recorded in the table.

* Abstract of paper by Mr. Frank Burgess, read before the Society of Automobile Engineers at the Detroit meeting, June 27-29, 1912.

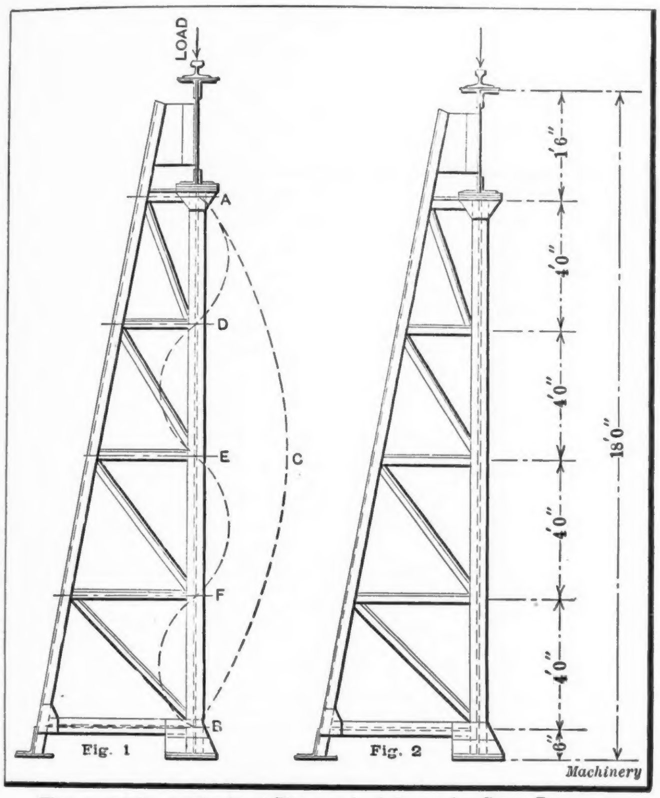
STRESSES IN AN A-FRAME FOR A CRANE RUNWAY

AN ANALYSIS OF THE PRIMARY STRESSES AND A DISCUSSION OF THE STRESSES IN THE LATTICE BARS

BY HARRY GWINNER*

Fig. 1 is an outline of an A-frame or trussed column for a crane runway. The following information has been requested in connection with it: "A discussion of the stresses in the members; a graphical analysis of the stresses; and an investigation into the influence that the other members have upon the perpendicular main member when choosing a section, as in the case of a column."

This frame will be treated as being subjected at different times to a different set of forces, which actually occurs in practice. In Fig. 1 the frame is shown as being subjected to a direct load along the axis of the main member *AB*. Under this load there is no tendency for the frame to rotate about the foot of the column *AB* (provided there is no eccentric stress in the column), and while the trussing does not receive any primary or direct stresses from this load, it does receive secondary stresses when the column begins to deflect under the load, or when the inevitable shortening begins to take place—that is, when the points *A* and *B* approach each other.



Figs. 1 and 2. Analysis of Stresses in A-frame for Crane Runways

The object of the trussing is to prevent buckling in the column at the points of attachment of the trussing, and will compel the member *AB* to assume the compound curve line, threading in and out of the column through the points of attachment *ADEFB* instead of bending along the single curve *ACB*, when deflection begins to take place. Thus the member *AB* may be treated as a column or strut of one-quarter of the length of *AB* (since the trussing as shown in the figure divides the length into four portions), so far as bending in the plane of the trussing is concerned.

To test the column to note the effect of the trussing or bracing, assume in Fig. 2 a direct load of 150,000 pounds, and the dimensions as shown. Assume a 15-inch by 42-pound I-beam for the column, and use the straight line column formula:

$$P = 16{,}000 - 70\frac{l}{r}$$

where

$P =$ permissible unit stress,

$l =$ length of column,

$r =$ radius of gyration.

Then we have for the permissible unit stress per square inch for the four-foot sections:

$$16{,}000 - 70\frac{4 \times 12}{1.08} = 12{,}890 \text{ pounds,}$$

1.08 being the least radius of gyration about the line 1—1, Fig. 3.

The permissible unit stress for the full length portion, taking the radius of gyration about axis 2—2, is:

$$16{,}000 - 70\frac{18 \times 12}{5.95} = 13{,}460 \text{ pounds}$$

Thus it will be seen that the trussing breaks the continuity of the column on the weaker side, and, hence, strengthens it materially.

Stresses in Truss Members

The stresses in the truss members are secondary ones, similar to those induced in the lattice bars of a built-up column. Some years ago the writer took up the matter of stresses in lattice bars with Prof. Mansfield Merriman—the author of the well-known work on "Mechanics of Materials" —who, at that time gave the information that no rational formula had been deduced for accurately computing the stresses. In an article on "Tests of Built-up Steel and Iron Compression Pieces," in the *Transactions of the American Society of Civil Engineers*, Vol. LXV, 1909, the results of the experiments undertaken showed that there is no simple mathematical law governing the distribution of the stresses in a latticed column, and in Bulletin No. 44, issued by the University of Illinois Engineering Experiment Station, on "An Investigation of Built-up Columns Under Load," a portion of the summary of the tests says: "It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical consideration or on data now available."

Hence, it is theoretically impossible to assign any definite values to the horizontal reactions, or the tendency to buckle at the connections of the trussing to the column. However, the following method is sufficiently accurate to determine the stresses for the purpose of proportioning the trussing. Using the formula $16{,}000 - 70\frac{l}{r}$ to get the permissible unit stress on the column, and with the assumption that the column is very short, 16,000 pounds per square inch will be used. The expression $70\frac{l}{r}$ may, therefore, be taken as the measure of the stress per square inch due to bending in the column under a direct load.

If l is in feet, this expression becomes $70 \times 12\frac{l}{r} = 840\frac{l}{r}$. Designating this stress per square inch as S, we have $S = 840\frac{l}{r}$. Then, by assuming a load put on the side of the column to produce this stress, we can more easily ascertain the stresses. Hence, place the column as shown in Fig. 4, loading it with a uniform load of w pounds per linear foot, and treat it as a beam. Then the beam will tend to deflect as shown by the dotted curve *xzy*. If the column is treated as being pin-connected at *A* and *B* in Fig. 1, it will have a tendency to assume the curve *ACB* shown in Fig. 1, which is very similar to he curve *xzy* in Fig. 4. Under his assumption, we may treat the bending in the column as if it were caused by the uniform load in Fig. 4.

Now, $\frac{wl^2}{8}$ is the bending moment in foot-pounds, or $\frac{12wl^2}{8}$ is the bending moment in inch-pounds. Then,

* Dean of Mechanical Engineering and Superintendent of Shops, Maryland Agricultural College, College Park, Maryland.

$$\frac{\text{Bending moment}}{\text{Section modulus}} = \frac{M}{Z} = S_1$$

Therefore,
$$\frac{12}{8} \times \frac{wl^2}{Z} = S_1.$$

Let I = moment of inertia,
C = distance from center of gravity to extreme fiber,
A = area of section,
r = radius of gyration.

Then,
$$Z = \frac{I}{C} = \frac{Ar^2}{C}$$, and, from the previous equation,

$$S_1 = \frac{12wl^2}{8} \times \frac{C}{Ar^2} = \frac{3wl^2C}{2Ar^2}$$

Therefore, as S and S_1 are approximately the same, $\frac{840l}{r} = \frac{3wl^2C}{2Ar^2}$ and solving for w, we have:

$$w = \frac{560Ar}{lC}, \text{ or total load} = \frac{560Ar}{C}$$

Therefore, R in Fig. 4 is $= \frac{560Ar}{Cl} \times \frac{l}{2} = \frac{280}{C}Ar.$

Having found R, treat the frame as for finding the stresses in a latticed truss, and as indicated in Fig. 5.

The writer recently requested sme information on trussed columns from two expert detailers and designers on columns employed by a bridge company with whom he was at one time employed. They both agreed that the most suitable way to handle such problems was to assume a deflection of two or three inches at the center of the column (after designing the column to take care of the direct load), and then to ascertain the amount of load which, when the column was treated as a beam, would produce this amount of deflection. The stresses at the different points along the beam (column), are proportional to the ordinates of the curve as shown in Fig. 4.

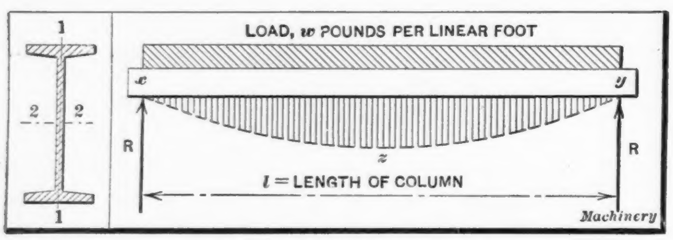


Fig. 3 Fig. 4. Column treated as Beam

Under this assumed deflection, the lengths of these ordinates can be measured on the supposition that this deflection, or elastic line, is a sinusoid, the equation of which is

$$Y = \triangle \sin x \sqrt{\frac{P}{EI}}$$

as given in Johnson's "Modern Framed Structures" under column formulas. This method is rather crude, but it has the advantage of giving something upon which to work.

The New Jersey Steel and Iron Co. has incorporated in its specifications the following clause: "The lattice bars shall be so spaced that each channel between the lattice connections shall be stronger than the column considered as a whole, and their size shall not be less than would be obtained by treating the column as a lattice girder supported at the ends and loaded at the middle with a load equal to 3 per cent of the total compression on the column. Mr. Pritchard, who was the engineer of this firm at one time, says the 3 per cent rule was first published in 1891 in the *Lehigh Quarterly*, and that it was adopted as a result of experience.

It is the opinion of the writer that the secondary stresses due to the direct load, as mentioned in the foregoing paragraphs, are very small, and that the theoretical sections required to take care of them are so small that these sections are impracticable, and that any structural shapes which are large enough for the rivets will be greatly in excess of any theoretical sections required.

In general, the practice is to entirely neglect these secondary stresses in crane frames and to design the trussing of such frames for horizontal loads. These horizontal loads are produced when the brakes are applied to the trolley traveling at right angles to the crane girders. The coefficient of sliding friction of the wheels on the rails is found to be about 0.2, and the maximum horizontal load possible, therefore, will occur when the brakes are so suddenly applied to the moving trolley carrying its maximum load, as to cause it to slide on the rails. Therefore, to proportion the trussing, assume 0.2 of the maximum vertical load plus 0.2 of the weight of the trolley applied horizontally at the rails of the runway girders, and design the A-frame as a cantilever for half this load, as it is assumed that the bridge girders of the crane

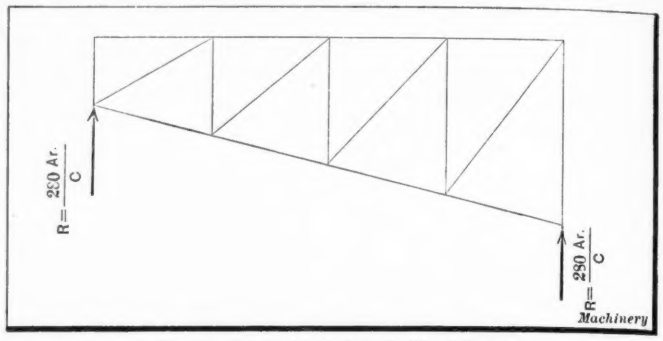


Fig. 5. Frame treated as Latticed Truss

transmit the other half to the opposite A-frame. The column AB (Fig. 1) is therefore designed to take the combined stress due to the direct vertical load and this horizontal load.

The A-frame is often used out-of-doors, and is therefore subjected to wind pressure, and often additional stresses are induced by the swaying of the live load carried by the crane or by an inclined pull caused by the load being out of plumb when the crane starts to lift it. All of these stresses must be considered and the design treated accordingly.

In the request for information that prompted this article, nothing was said relative to the stresses induced by forces in a plane at right angles to the plane of the trussing. If the moment of inertia of the cross-section of the column is not sufficiently strong to take care of these forces, side bracing should be used. The calculation of this bracing is made in a manner similar to that of the portal or intermediate bracing in a bridge.

* * *

COURT DECISION ON EMPLOYERS' LIABILITY

A recent unanimous decision of the Illinois Supreme Court in the suit of Milford Streeter of Aurora, Ill., against the Western Wheeled Scraper Works, establishes a new basis for the relation between employers and employes as regards accidents and accident prevention, this new basis being a consequence of the new state employers' liability law of Illinois, which is similar to those enacted in several of the other states. The court, affirming the decisions of two lower courts, holds that the old law, under which an employe could not recover if he knowingly worked on defective or unsafe machinery, is now a dead letter. The wording of the conclusion of the court's decision is as follows:

"The law does not leave to the employer's judgment the reasonableness of inclosing or protecting dangerous machinery, or permit him to expose to increased and unlawful dangers such of his employes as may be driven by force of circumstances to continue in his employ rather than leave it and take chances of obtaining employment elsewhere under lawful conditions. The guarding of the machinery mentioned in the statute is a duty required of the master for the protection of his workmen, and he owes the specific duty to each person in his employ. To omit it is a misdemeanor, subjecting him to a criminal prosecution."

* * *

The oldest metallic objects to which archaeologists have assigned a probable date are those found at Nagada in Egypt. These consist of some pieces of gold, a bead, a button and fine wire of nearly pure copper, which are supposed to be at least 6300 years old. Nearly all the ancient gold that has been examined contains silver enough to give it a light color.

SELECTING THE NUMBER OF TEETH FOR GEARS AND SPROCKETS*

BY G. M. BARTLETT†

The tables in the accompanying Data Sheet Supplement contain the decimal equivalents of all fractions with denominators up to 60. In machine design it is frequently necessary to determine gears and sprockets with low numbers of teeth to give approximately such ratios as can be expressed exactly only with very high numbers of teeth. For example, in a certain machine employing a chain drive, it is required to have the speeds of the driving and driven sprockets as near as possible to 1149 and 473 revolutions per minute. It is stipulated, however, that the number of teeth in the larger sprocket must not exceed 60. Dividing 473 by 1149, we find that the ratio is 0.4117. By referring to the table of fractional equivalents given in the accompanying Data Sheet Supplement, the nearest fractional value to this ratio, with a denominator less than 60, is found to be 7/17. Hence, the number of teeth in the two sprockets can be 14 and 34, or 21 and 51. This will give speeds of 1149 and 473.118 which introduces a comparatively small error. In the absence of such tables, the method of obtaining the approximate fraction 7/17 would be rather cumbersome, as will be seen from the following:

```
473 | 1149 | 2
       946
      ----
       203 | 473 | 2
             406
             ---
              67 | 203 | 3
                   201
                   ---
                     2 | 67 | 33
                         66
                         --
                          1 | 2 | 2
                              2
                              -
```

This is the operation by which the greatest common divisor is sometimes found. Next, place the partial quotients obtained in a row as below. Beneath the first number, write its reciprocal ½. Beneath the second number write a fraction, the numerator of which is the second number itself, and the denominator of which is the product of the first and second numbers plus 1. For the numerator of the next fraction, multiply the partial quotient (3) by the numerator of the second fraction (2), and add the numerator of the preceding fraction (1). The result is 7. For the denominator, multiply the partial quotient (3) by the denominator of the fraction just found (5), and add the denominator of the preceding fraction. The result is 17. Proceed in the same way for the succeeding fractional values, the method used being that of continuous fractions.

$$\begin{array}{ccccc} 2 & 2 & 3 & 33 & 2 \\ \frac{1}{2} & \frac{2}{5} & \frac{7}{17} & \frac{233}{566} & \frac{473}{1149} \end{array}$$

These fractions approach the value of 473/1149 as we proceed towards the right, but as we cannot use more than 60 teeth in the sprocket, the fraction 233/566 cannot be used. Hence, we must use the fraction 7/17, or, if this fraction does not give a sufficiently close approximation, we must use some fraction between 2/5 and 7/17 that might come closer to the required ratio and which has a denominator less than 60. Between the values of 2/5 and 7/17 there are, then, the following fractions: 23/57, 21/52, 19/47, 17/42, 15/37, 13/32, 24/59, 11/27, 20/49, 9/22, 16/39, and 23/56. Whether or not any of these gives a closer approximation, can only be found by trial. In the present case, of course, the matter would be easily determined, as 7/17 comes so very close to the required ratio.

As another example, suppose it is desired to feed stock to a punch press through rolls of 4-inch diameter, the rolls being turned by a ratchet and pawl at the end of each stroke of the punch. The feed is to be as near as possible to 2¼ inches, and the number of teeth in the ratchet to be as low as possible. To find the answer to this problem with the aid of the tables in the Data Sheet Supplement, we proceed as follows: The feed for one revolution of the rolls is $4\pi = 12.5664$. To feed 2¼ inches, the rolls must make $2.25 \div 12.5664 = 0.1790$ of a revolution. Referring to the table, the nearest fraction to this ratio is 5/28; hence we choose a ratchet of 28 teeth, feeding five teeth at a stroke. The feed will be 2.244 inches instead of 2.25 inches, an error of only 0.006 inch. If we should choose the next higher fraction to the ratio 0.1790, which is 7/39, the ratchet will have 39 teeth, and the feed of seven teeth in this ratchet will be equivalent to a feed of 2.256 inches, which also involves an error of 0.006 inch.

If a plate cam is to be cut on a lathe, and it is necessary to feed the tool 0.53 inch for each revolution of the cam, and the lathe is so constructed that it takes 10.35 revolutions of the lead-screw to feed the tool 0.53 inch, the change gears must be so selected that there will be a velocity ratio of 1 to 10.35 between the work-spindle and the lead-screw. Two pairs of gears will be required. Assume the ratio of the intermediate gears arbitrarily as 1 to 3; it remains to find a combination with a ratio as near as possible equal to

$$3 \times \frac{1}{10.35} = 0.2899$$

Referring to the Data Sheet Supplement, the nearest fractions to a ratio of 0.2899 are 11/38 and 9/31. As change gears with multiples of these numbers of teeth are usually not available, we take the nearest available fraction, which is 7/24, giving gears with 28 and 96 teeth, respectively. The ratio 1/3 can be obtained by using gears with 24 and 72 teeth, and the value of the train of four gears, hence, is:

$$\frac{96 \times 72}{28 \times 24} = 10.286$$

which gives a feed of 0.527 inch per revolution instead of 0.530 inch, an error of only 0.003 inch.

Problems in cutting racks for gears of a given diametral pitch, or in cutting screw threads of unusual leads may be considerably simplified by the use of this table.

* * *

* With Data Sheet Supplement.

† Chief Engineer, Diamond Chain & Mfg. Co., Indianapolis, Ind.

IMPROVEMENTS IN GAS ENGINE DESIGN

BY GEORGE M. STROMBECK*

In gas engine design, as well as other matters, experience is the court of last appeal. When any particular practice has stood the test of years, it is not safe, except through knowledge gained by unusually wide practical experience, to condemn it, as there may be reasons for its existence that outweigh the theoretical objections to it. This is especially true in an industry where competition is so keen as in the gas engine business. While much of Prof. Hirshfeld's criticism of gas engine design in the July number of MACHINERY is justified, he attacks a number of things which the writer, after five years' shop experience, believes to be sound practice.

In regard to overhanging cylinders, it is doubtful if anyone would justify the construction in Fig. 1 of the previous article, but the modification hinted at in Fig. 2 and further developed in the accompanying illustration has much to commend it: first, the entire length of the cylinder on all sides is free to expand, and, second, the metal is uniform at all places; these are both the best possible conditions under which a cylinder can retain its shape, thus permitting lighter rings with consequent reduction in engine friction and wear. From a manufacturing point of view the construction is simpler than that shown in Fig. 4 (former article), because all the work can be done at one setting and in a lathe, making it easy to obtain true work. In reference to Fig. 4, every shop man knows that this design involves at least two settings for machining, and this increases the cost. Furthermore, there is a chance of getting the guides out of line with the bore; moreover, some parts of the cylinder section are heavier than others, and as the ribs are bolted to the frame there is a possibility of undue stresses not present with the overhanging cylinder. The makers of a very widely known and successful engine have manufactured over twenty thousand with an overhanging cylinder during the last dozen

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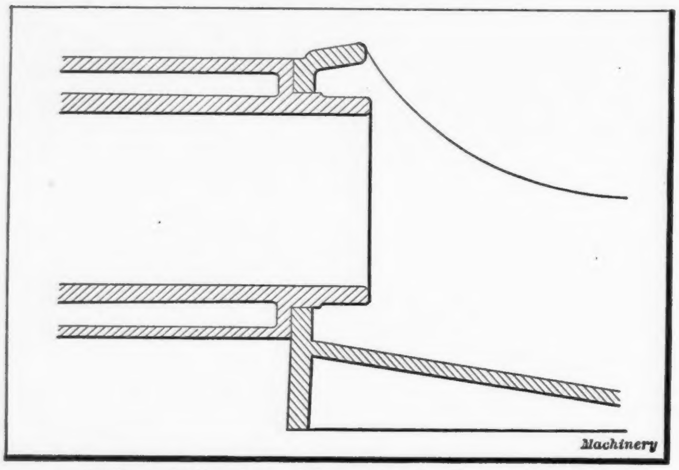
years, and have had no trouble whatever from them. In fact, they are so pleased with their performance that they are continuing this feature in a new line now being brought out.

Another point in design which the writer believes has more to justify it than to condemn it is the direct connection between the water jacket in the cylinder and in the head, Fig. 9. That solution of a problem which is direct, and, all things considered, saves most time, must be conceded to be the best engineering practice. Reasonable care in the machining of the ends of the cylinder and head will produce a surface that readily holds a gasket. The only time when trouble would be experienced would be when a part of the circumference is subjected to a much higher temperature than the rest, and when this is the case it would probably be difficult to make a tight joint even though the water jacket were not cut through. If only a part of the extra work necessary to provide other means of cleaning the jacket is applied to making the joint between the head and cylinder right, the trouble with the jackets will not be enough to deserve mention. Any other method would first of all deprive the foundry of a most positive means of holding and venting the jacket core, with a resulting higher loss of castings (with same care and labor). The cleaning out of the core sand and, later,



Method of Attaching and Supporting Gas Engine Cylinder

removing of scale would be much more difficult and far less certain if pockets or hand holes were used. There is a remarkable agreement among manufacturers in this point of design, which would not be the case had their experience proved to them that the present methods were wrong.

A minor point in design is the oil groove around the base. While this, no doubt, serves to collect some oil which would otherwise reach the floor, it is doubtful whether the advantages gained offset the foundry difficulties. To be of service, such a groove must be continuous, which can only be done by bringing it outside of the bosses for the anchor bolts. If this is done, larger flasks and the handling of more sand is necessary; but more objectionable than this is the fact that the sand forming the grooves is poorly supported, requiring careful securing. Even then it may wash away in pouring the casting. These objections have been sufficient to cause the removal of such a drain from such engines as were at first designed with it.

The splash collar on the crankshaft, Fig. 15, is, in theory, a fine thing, but its cost is disproportionate to its advantages. While it looks innocent enough, such a little knife edge would add a very large percentage to the cost of grinding the shafts, which is the present practice. With a straight shaft the operation is simple; with a splash collar more or less complication would be introduced, and much greater care in handling the finished product would be required. The splash collar is a refinement which a very large majority of users of small and medium sized engines would not want to pay for.

The use of malleable iron for connecting-rods is, according to experience, anything but an objectionable practice. The maximum return for minimum effort, that is, the cost, must determine this as well as all other problems in engineering manufacture. In small sizes, steel drop-forgings are the solution. In larger sizes, this is out of the question, and the designer must choose between the turned rod and a cast one. If he wishes the benefit of the economical I-section, the material must either be steel casting or malleable iron. The art of casting steel is not as advanced as that of casting malleable iron; hence, there is more uniformity with the latter.

William Kent, in the latest revised edition of his "Pocketbook," says, on page 430, of malleable iron: "For the repeated stresses of severe service the malleable casting ranks ahead of steel, and only where a high tensile strength is essential must it be replaced by that material." On page 431 he says: "The effect of annealing is to oxidize and remove the carbon from the surface of the casting, to remove it to a greater or less degree below the surface, and to convert the remaining carbon from the combined form into the amorphous form called a 'temper carbon' by Professor Ledebur, the German metallurgist. * * * In the American practice the annealing process is rather a heat-treatment than an oxidizing process." On the following page Mr. Kent says: "It was formerly the general belief that the strength of malleable iron was largely in the white skin always found on this material, but it has been demonstrated that the removal of the skin does not proportionately lessen the strength of the casting."

The above statements agree exactly with the writer's experience with malleable iron connecting-rods. Barring accidents, there has been no trouble with such rods. The effect of inertia on the rod, to be sure, makes it a beam under a continuous load, but this load does not act when the rod is under its greatest stress, nor is it at any time very large in engines of the size that are usually fitted with malleable-iron rods. Hugo Güldner, in his excellent book on gas engine design, gives the maximum bending moment M_b in the plane of the motion of the rod, caused by the inertia, as follows:

$M_b = 0.000002\ n^2 r A g L^2$, where

n = revolutions per minute,

r = radius of crank in inches,

A = area of mean section of rod in square inches,

g = weight of one cubic inch of the material of the rod in pounds,

L = length of rod in inches.

Applying this to an actual case will show the relative unimportance of this bending stress. An engine making 350 revolutions per minute has a connecting-rod 27 inches long. The mean section is I-shaped and has an area of 1.65 square inches, and a moment of inertia of 1.09. The bore is 6½ inches, and the stroke is 11 inches. Substituting in the formula:

$M_b = 0.000002 \times 350 \times 350 \times 5.5 \times 1.65 \times 0.26 \times 27 \times 27 = 421$ inch-pounds.

The rod section is 2¼ inches deep. The fiber stress is then, according to the usual formula:

$$S = \frac{M}{I/C} = \frac{421}{1.09 \div 1.125} = 435 \text{ pounds per square inch.}$$

When it is remembered that this stress does not occur until after the maximum force of the explosion has been exerted, it is plain that it needs but little consideration, and that the use of malleable iron in the connecting-rod is not objectionable.

Concerning the low-tension ignition system, it would seem singular that manufacturers should adhere to it so strongly if there were not much in its favor. Equally singular would it seem that all leading manufacturers of magnetos are now developing low-speed, low-tension magnetos for make-and-break service, if they did not believe in this system. The sooting up and fouling of spark plugs even with automobiles is proverbial. If this is the case in an engine which explodes regularly every cycle, what is to be expected in a hit-and-miss engine on a light load, where the explosions are far apart, giving plenty of time for lubricating oil and soot to foul the plug? With the make-and-break ignition, the motion of the igniter prevents this. The practice of the manufacturers is the result of the experience of numerous experts, continually in the field, who have had full opportunity to compare both systems under all conditions.

MANUFACTURING THE VIXEN FILE*

METHODS USED IN PRODUCING A CIRCULAR CUT FILE

BY CHESTER L. LUCAS†

Since the days when primitive man used the file for sharpening his implements of field and war, the file has been one of the most common tools. As in many other commonplace things, however, no one seemed to see room for improvement until, in 1900, Alexis Vernaz, of Yverdon, Switzerland, was trying to devise a hand tool for cutting a lot of exceptionally hard castings. The Vixen file was the result of his efforts. His whereabouts is not known at present, but there is an Elliott Cresson medal waiting for him that was awarded by the Franklin Institute in 1909 for making the first radical improvement in files for generations. The essential points of the Vixen file are well described by a sentence from the patent specifications: "A file provided with teeth cut in the form of arcs, having their bases located rearwardly with respect to the cutting edge of the teeth."

Fig. 1 illustrates a Vixen file, in which it will be seen that the radical difference between it and the ordinary file lies in the shape of the teeth. The object of curving the teeth is to provide a shearing cut, and by reason of this shearing cut

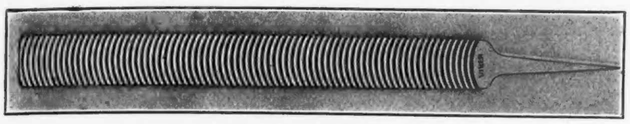


Fig. 1. The Vixen File

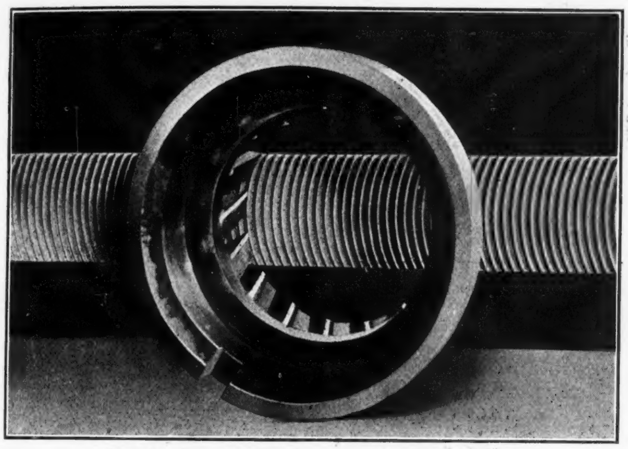


Fig. 2. How the Teeth are cut on Vixen Files

the file is self-clearing. The determination of the radii of the arcs of the cutting teeth of the various sizes of files was the result of experiments which indicate that the best cutting tooth is obtained by using a radius approximately the width of file being made. Teeth cut on smaller radii in proportion to the width of the file make it impossible to guide the file correctly, and teeth of much larger radii do not cut nor clear as easily. The teeth of Vixen files are milled with hollow cylindrical cutters. Several of these cutters are shown in

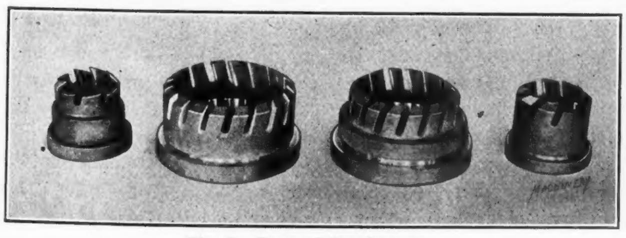


Fig. 3. Four of the Cutters

Fig. 3. Of necessity, the cutter is slightly inclined to the face of the file while cutting the teeth, in order that the side of the cylindrical cutter not being used may clear the parts of the file not being cut. This condition is graphically shown in Fig. 2. The amount of this inclination varies from 2 to 4 degrees, depending on the different depths of cut. By thus inclining the cutter to the work and securing a rake to the teeth, an added quality is given to the tooth, enabling it to cut rapidly. The inclination of the axis of the cutter results in cutting the teeth slightly deeper at the center than at the edges, therefore, the face of the finished file is slightly lower

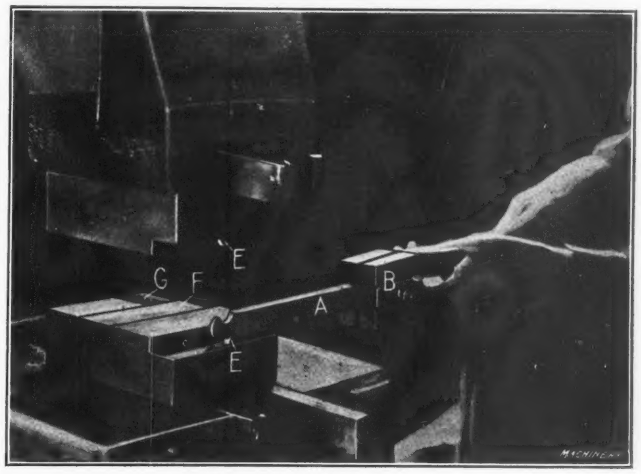


Fig. 4. Forging the Tang

in the center, the amount, however, is so small that it is practically imperceptible.

Steel for Vixen Files

The steel from which Vixen files are made is a Swedish chrome steel and is ordered on specification calling for chemical analysis as follows:

Carbon	1.20 to 1.35 per cent (1.25 per cent desired)
Chromium	0.40 to 0.60 per cent (0.50 per cent desired)
Manganese	not to exceed 0.40 per cent
Silicon	not to exceed 0.30 per cent
Phosphorus	not to exceed 0.03 per cent
Sulphur	not to exceed 0.03 per cent

The hardness, according to the Brinell hardness scale, should be from 130 to 170, a hardness of 150 being desired.

Operations in Making the File

The first operation in the making of the file consists in the shearing of the bar stock to length. This is an

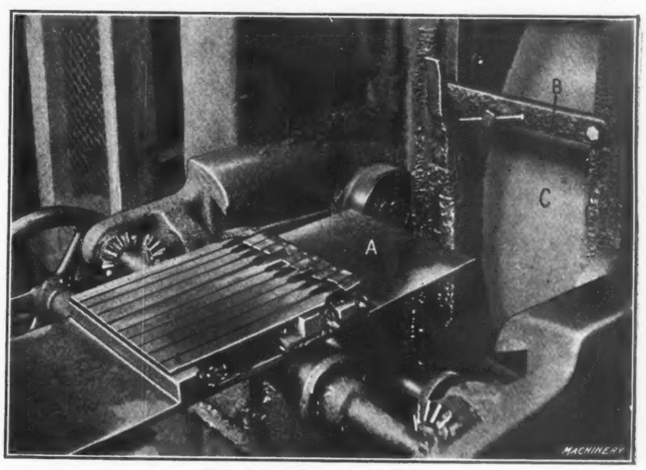


Fig. 5. Grinding the Sides

ordinary operation and is performed upon a shearing press of the usual type. From the shearing press the short lengths of steel go to the tanging hammer where the tangs of the files are forged in the manner illustrated in Fig. 4. The dies, and the beginning of the tanging operation are here illustrated. A helper hands the file blank, one end of which has been heated to a forging heat, to the operator of the hammer in which the tangs are forged. The blank *A* is held in special tongs *B*. The first part of the tanging operation consists in "nicking" the end of the file blank between the two half rounded projections *E* at the front of the dies *C* and *D*, leaving

* For further information on file making, see the following articles in MACHINERY: "File Making at a Sheffield Works," April, 1911, engineering edition; "Toolmakers' Files," January, 1911; "Vernaz Circular Cut File," October, 1909; "Making Swiss Files in America," September and October, 1907. See also MACHINERY'S Reference Book No. 48, "Files and Filing."

† Associate Editor of MACHINERY.

the file blank in the condition shown. After this blow the operator shifts the file blank to the middle section *F* of the dies which have beveled faces corresponding with the taper of the tang. By rapidly turning the blank after each blow, the metal beyond the nicked portion of the blank is drawn out to approximately the shape of the finished tang, after which one or two blows are struck on the finishing faces *G* of the die to complete the tang. It is an almost incredible fact that the tang of an 8-inch file is forged in from ten to fifteen seconds from the time it is taken from the fire.

Following the tanging operation, the trademark impression is stamped upon the shank of the file, after which the blanks are annealed by being heated in large quantities in iron boxes and allowed to cool very gradually. The annealing operation decarbonizes the exterior surface of the steel, and before cutting the teeth it is important that this inferior surface of the stock be faced off. This operation, called stripping, is common in making files of all kinds, the metal being removed on large broad-faced grindstones, six feet in diameter. The files are held by the tangs on the plate shown at *A* in the illustration Fig. 5, which is dropped into position against the wheel and clamped by bar *B*, after which the holding plate and files are reciprocated in a vertical line against the face of the wheel *C*, at the same time being flooded with water and fed gradually against the wheel. By this means, 1/64 inch is removed from each side of the file-blanks, leaving them perfectly flat and ready for the cutting of the teeth.

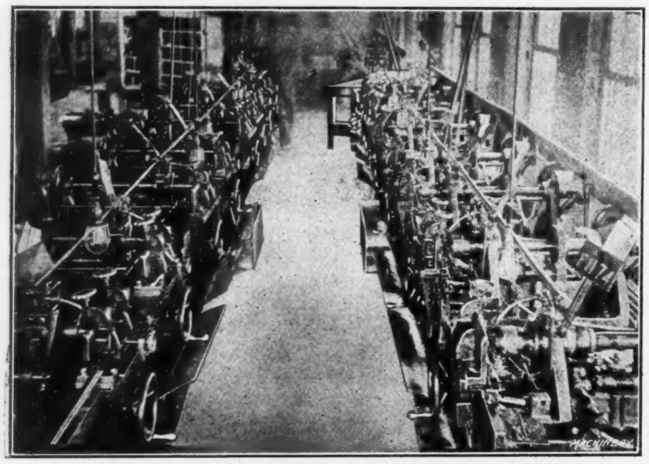


Fig. 6. Two Groups of the Tooth-milling Machines

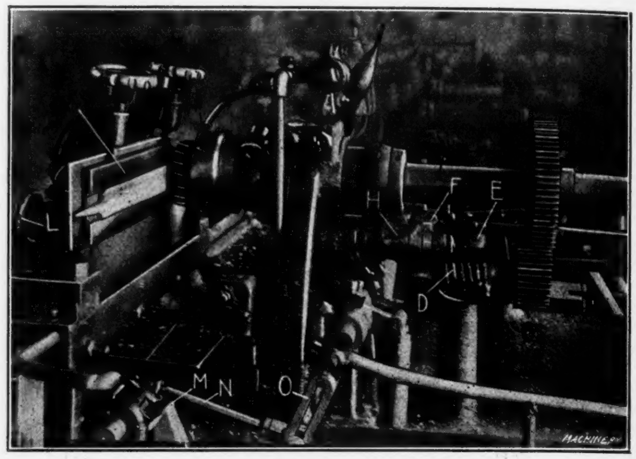


Fig. 7. Details of Machine for Milling Teeth

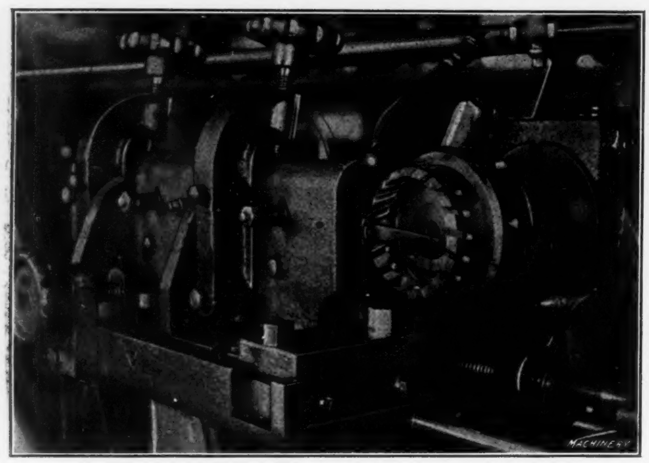


Fig. 8. Close Range View of Cutting Head

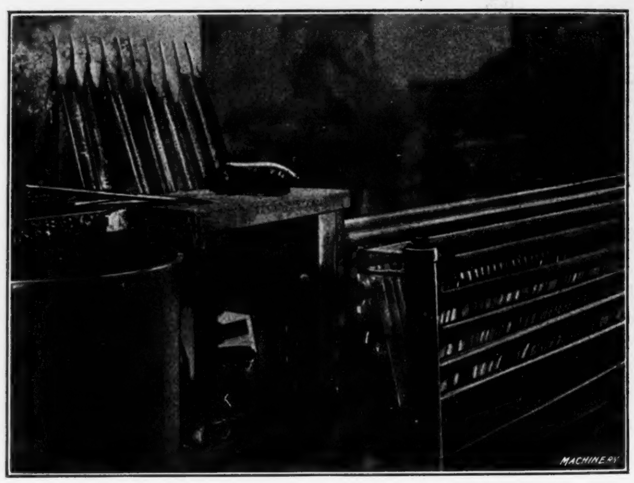


Fig. 9. Preparing the Files for heating in the Lead Bath

Cutting the Teeth

The most interesting operation in connection with the making of the Vixen file is the cutting of the teeth. The machines for cutting the teeth are operated in groups of eight, being driven from lineshafting at the rear of the rows of machines. Two of these groups of machines are shown in Fig. 6. The machine consists essentially of a spindle which carries the cylindrical cutter and a table which supports the file blank in a plane at right angles to that of the cutter spindle. As the cutter revolves, it is fed forward to the file blank, withdrawn, the file holding table moved forward the distance of one tooth and the cutter spindle brought forward again. Thus, the teeth are cut one at a time and the machine is automatically stopped after the last cut. Referring to Fig. 7, the cutter spindle, its method of feeding and the cross feed of the work table, may be seen. The cutter spindle shown at *A* is driven by bevel gearing from the extreme right-hand end of the machine. By means of gear *B* in mesh with gear *C* operating on a worm-shaft, the worm *D* engages a worm-wheel, not shown, which causes cam *E* to turn against yoke *F*. Yoke *F* is attached to collar *G*, and thus as the high part of the cam is reached, the cutter is fed forward to its deepest position with respect to the file and, of course, returned when the low part of the cam is reached. The double spring box *H* constitutes a means for insuring the feeding of the cutter to the proper depth of the tooth in each instance; the springs within the barrels overcoming any tendency for uneven feeding of the spindle caused by chips lodging upon the cam or from other sources.

The cutters themselves are made of Rex high-speed steel. Four of these cutters are shown in Fig. 3, and, as may be seen, they are milled very deep between the teeth, which allows them to clear themselves of chips rapidly and provides for many sharpenings before they are worn out. The cutting faces are ground to an included angle of 60 degrees and the cutter is held to the end of the spindle by a flanged sleeve *I*, shown in Fig. 7, which is tightened by a spanner wrench holding the cutter securely in place. The illustration Fig. 7 also shows the method in which the files are held for cutting, consisting of the two clamping screws *J* which operate against jaw *K* of the vise. For varying the depth of the tooth, handwheel *L* is used, thereby bringing the work table nearer to or farther from the cutter. The number of teeth cut per inch varies from 6 2/3 to 16, and for spacing the teeth there is a ratchet and pawl upon the end of the feed shaft. This pawl, shown at *M* in the illustration Fig. 7, is operated by a lever *N* which, in turn, is reciprocated by the arm *O*. Another view of this machine is shown in Fig. 8 which more clearly shows the cutter and its relation to the file blank.

The widths of the files vary from ⅞ inch to 1¾ inch.

There are, on each side, from 90 to 250 teeth, varying, of course, with the pitch and length of the file. It takes twenty-five minutes to cut the teeth in one side of an ordinary 12-inch Vixen file, as compared with one minute for cutting the teeth on one side of an ordinary commercial 12-inch file. Hence it is apparent that the manufacturing cost of a Vixen file is comparatively high.

Hardening

Previous to heating the files for hardening, they are treated with a charcoal and oil preparation to prevent the lead used in the heating from clinging to the teeth and thus interfering with the hardening. The files are brushed with this solution and placed against racks of steam pipes as shown in Fig. 9, to bake the coating on before the files are placed in the lead pot.

The molten lead in which the files are heated is kept at a temperature of 1400 degrees, its condition being indicated by a Bristol pyrometer. Several files are kept heating in the lead pot, being immersed to the tangs. A bar across the top of the lead pot holds the files beneath the surface of the

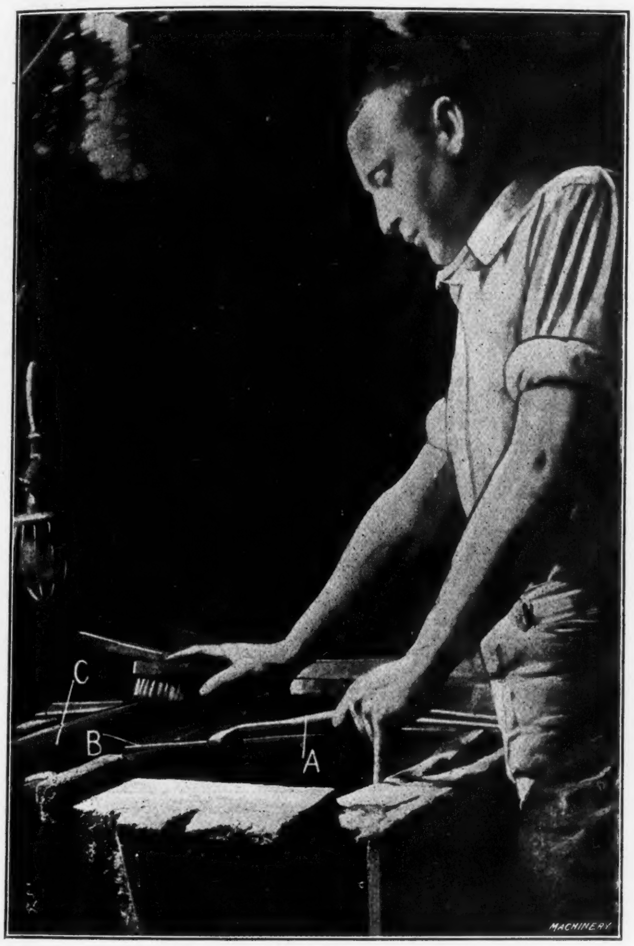


Fig. 10. The Cold-straightening Operation

molten lead so that they may be heated slowly and evenly. A file is taken from the lead pot by the hardener, and before being quenched in the brine solution in which the files are hardened, the red hot file is rapidly straightened across lead blocks with a wooden faced hammer. This operation, which is shown in Fig. 11, is necessary on account of the strains set up in the steel by the milling of the teeth. After straightening, which takes but a few seconds, the file is plunged straight down into the brine and moved rapidly up and down until the "singing" has nearly ceased. The file is then quickly removed, sighted, and again straightened after the manner shown in Fig. 10. For this purpose the file is clasped in an iron holder, *A*, after sighting, and placed with the high side down against the wooden bar *B*, the tip end of the file being caught under bar *C*. Pressure is then applied to straighten the file and cold water splashed upon the upper side to bring the file back to a straight condition. This operation of straightening requires a great deal of judgment, for, if the file is kept in the hardening tank a few seconds too long, it will break when pressure is applied for straightening, and on the other hand if removed too quickly, the temper of the file will be impaired.

Sharpening the Files

From the hardening department the files go directly to the sharpening machines. Unlike the sharpening of most tools, files are sharpened by being passed over jets of steam which is mixed with a cutting paste made with a fine mineral abrasive powder. The sharpening machine shown in Fig. 13 is equipped with three nozzles which are shown being used

Fig. 11. Straightening Hot Files

in the operation of sharpening Vixen files. The base of the machine contains the sharpening paste which is led to the nozzles of the steam pipes and thus is propelled against the sides of the file when it is moved backward and forward over the nozzle. A spool, shown just above the nozzle, is used to keep the file at the proper distance from the nozzle. In

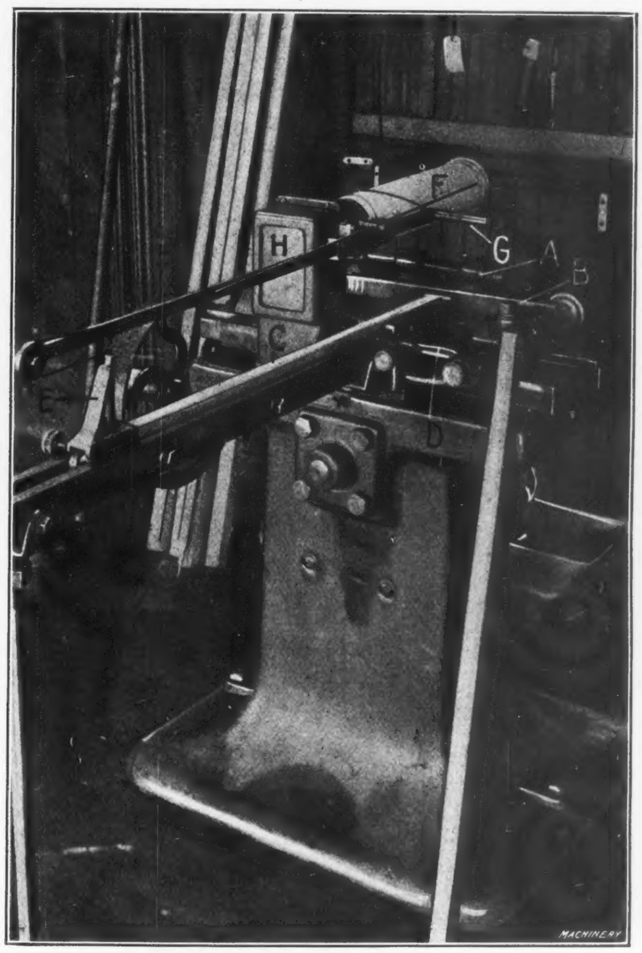


Fig. 12. Herbert File Testing Machine

addition to removing all dirt and scale from the files, this operation sharpens the file by cutting away a slight amount from all parts of the file which it strikes. The files are held by the tangs and in passing over the nozzles, the abrasive material strikes the teeth from the back. If the operation were reversed and the files fed in from the points, the sharpness of the teeth would be removed and the files dulled instead of sharpened. For testing the sharpening, "provers"

are used. These provers consist of short pieces of soft steel which are drawn over the file by hand. Even to those unaccustomed to this work, the prover indicates the fact that the file has been really sharpened, and to the sharpener the prover reveals any sections of the file which are not quite up to standard sharpness. Lime is added to the special sharpening compound to prevent the files from rusting after they leave the sharpening machine. The final operation consists in cleaning out the file under a jet of live steam, and after oiling, the files are ready for use.

Testing Files on the Herbert File Testing Machine

A Herbert file testing machine, shown in Fig. 12, the working parts of which are shown in detail in Fig. 14, forms the

Fig. 13. Sharpening the Files

only practical method of testing the cutting and enduring qualities of the file. This machine was described in detail in MACHINERY, December, 1907, and is also described in MACHINERY'S Reference Book No. 48, "Files and Filing." Briefly stated, the machine consists of a reciprocating file holder *A* in which the file *B* is held, backed up by suitable supports. The file is reciprocated across the end of the square test bar *C* at the rate of 50 strokes per minute. On the return stroke, the bar is withdrawn slightly by means of arm

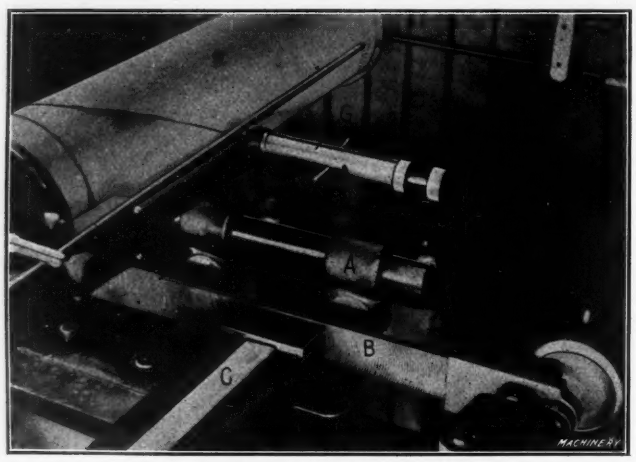


Fig. 14. Details of the File Testing Machine

D. The forward feeding of the bar is accomplished by means of a 30-pound weight which is attached to the bar at the front of the machine by a chain running over a pulley. The rate of forward travel of the bar is recorded on the chart *F*, by the pencil held in the holder *G*. By means of clockwork within the case *H*, the chart cylinder is turned slowly, with the result that a curve is traced upon the chart which indicates the cutting efficiency of the file tested.

Credit is due to Mr. W. D. Craft, manager, and Mr. C. M. Zubler, superintendent of the Vixen Tool Co., Philadelphia, Pa., for courtesies shown the writer in the preparation of this article.

* * *

Muzzling the gears may not stop them from biting, but it promises to muffle the bark.

MAKING THE FOSTER SAFETY SET-SCREW

BY CHESTER L. LUCAS*

In the new factory of the New Haven Machine Screw Co., New Haven, Conn., which appears in Fig. 1, a considerable part of the work consists in the making of the Foster safety set-screw. The factory is of reinforced concrete, and in designing the building, special attention was given to the lighting system; as may be seen, almost all of the wall space is taken up by windows. Fig. 2 shows a view of the automatic

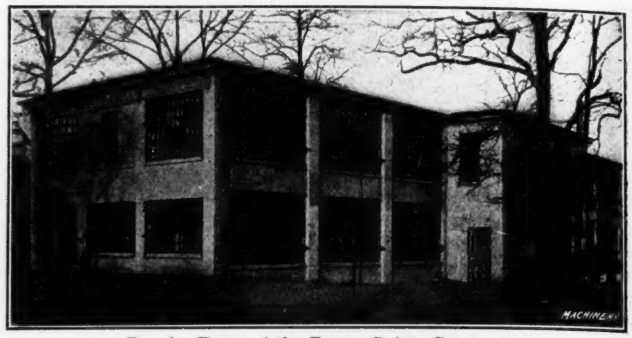


Fig. 1. Home of the Foster Safety Set-screw

turret lathe department in which the blanks for the set-screws are made. Low carbon steel is used in making the set-screws. The turret lathes used are of the multi-spindle type, operating on four bars of steel at once, and when the blanks are dropped from these machines they are in the condition shown at *A*, Fig. 3, having the point roughly shaped, the opposite end rounded, and the stock drilled from the central hole.

In the second operation the hole is broached to a hexagonal

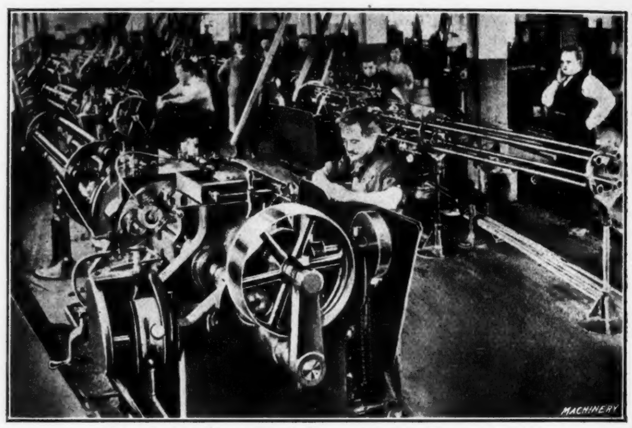


Fig. 2. The Automatic Turret Lathe Department

shape.† This operation is performed in a punch press, using the attachments shown in Fig. 4. Referring to this illustration, *A* is a dial revolving on a stud *B* which is fitted to the bed of the press. Around the edge of this dial, bushed holes are spaced to receive the set-screw blanks being broached. The dial is turned, bringing each of these holes successively under the broaching punch *C* by means of an indexing arrangement at the side of the press. This indexing arrange-

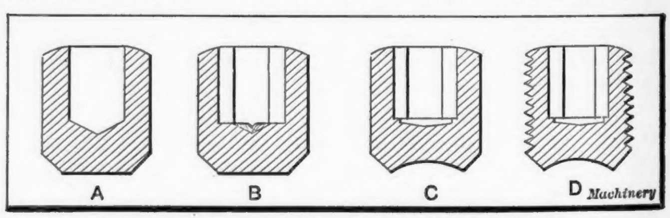


Fig. 3. The Four Steps followed in Making the Set-screws

ment consists of a lever *D* fulcrumed on the stud *E* and operated from the main shaft of the press. At the lower end of the lever, motion is transmitted to an arm *F* which reciprocates the indexing pawl *G* at each return stroke of the press ram. In broaching, the operator places the blanks in the holes in the revolving dial, and as they are indexed to the position under the punch, they are broached. Upon reach-

* Associate Editor of MACHINERY.
† A method of progressively broaching square holes in socket wrenches was described in the March, 1902, number.

ing the position directly under finger *I*, they are ejected from the dial by being pushed out by this finger at the down stroke of the press. By referring to *B*, in Fig. 3, which shows the result of this broaching operation, it will be noticed that the metal removed from the six corners of this hole is pushed into the conical end of the hole. In order to clear out these chips and make a neater looking hole, the set-screws are re-drilled in the machine shown in Fig. 5. This machine works upon the blank from both ends, the blank being held by means of jaws *A* and *B*, of which jaw *A* is movable and

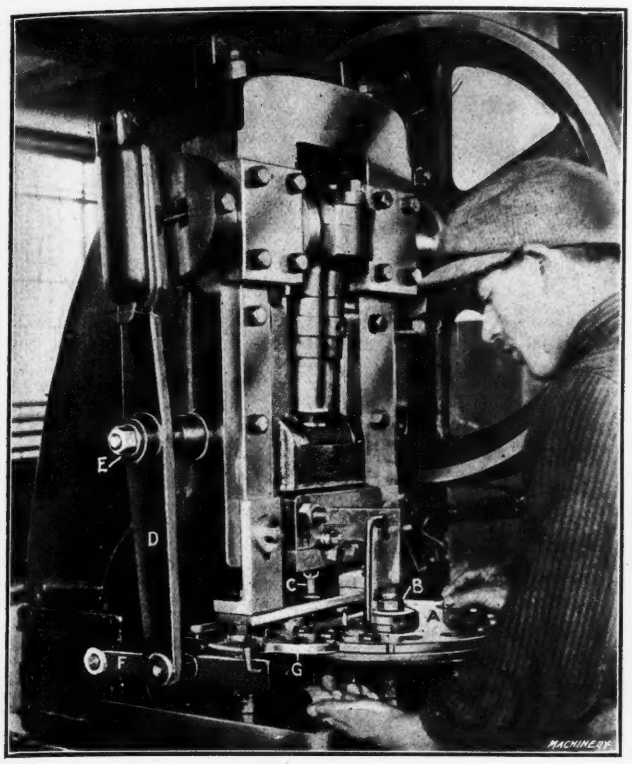


Fig. 4. Broaching the Holes

is clamped upon the work by the foot pressure of the operator. In re-drilling it is only necessary to remove enough metal to clear out the chips and leave the bottom of the hole clean. While re-drilling the blank set-screws from the one end, a forming tool is countersinking and shaping the point of the set-screw, and when taken from this machine the set-screw has assumed the shape shown at *C* in Fig. 3, and is ready for threading.

The threading of Foster safety set-screws is performed on Geometric threading machines, and the details of the thread-

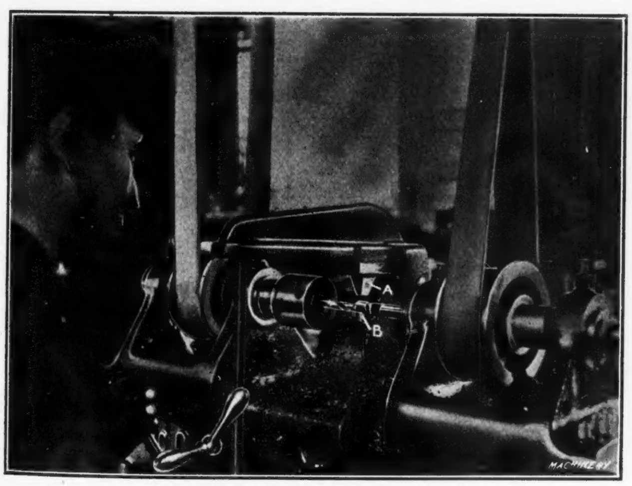


Fig. 5. Re-drilling the Hole and Cupping the Point

ing operation appear in Fig. 6. The machines are equipped with Geometric self-opening dies, and, for threading, the blank set-screw is held upon a short hexagonal arbor, the carriage is run up by hand, and the blank led into the dies. The set-screws are then casehardened by a special process after which they are ready for shipment, the finished set-screw appearing as shown at *D* in Fig. 3.

GENERATORS FOR THE KEOKUK POWER PLANT

The General Electric Co., Schenectady, N. Y., is building a number of very large electric generators for the hydro-electric power plant at Keokuk, Iowa, where ultimately 300,000 horsepower will be developed from the water power of the Mississippi River. This hydro-electric development has been made possible by the building of the greatest power dam ever constructed. The dam is built entirely from concrete. It has a total length of 9096 feet and rises 50 feet above the average river bed. The initial electric installation consists of fifteen alternators connected to the same number of vertical hydraulic reaction turbines of the single runner type. Each turbine and generator form an independent unit. The turbines are mounted on vertical shafts 25 inches in diameter, and will operate at a speed of 57.7 revolutions per minute, the normal capacity being 10,000 horsepower. The generators are installed on the top of the wheel pits directly over the turbines and will generate a three-phase alternating current at 11,000 volts. Transformers will be installed for stepping up the voltage of the current which is to be distributed over the high-tension transmission lines to 110,000 volts. The power will be distributed within a zone of 150 miles radius. Owing to the slow speed of the generators, their dimensions are very large. They are 32 feet in diameter and 12 feet high, the total weight being over 300 tons. One of the cities to

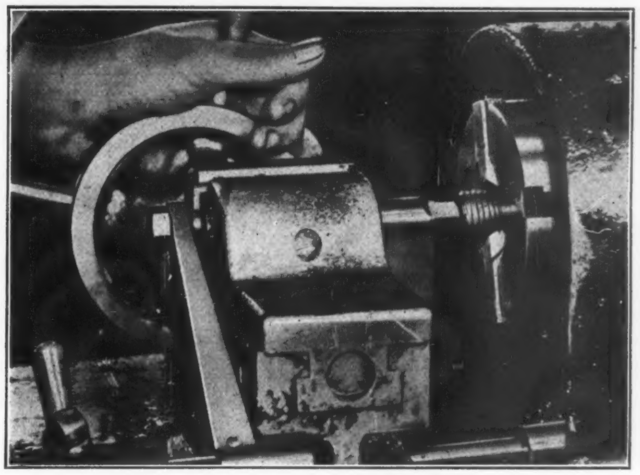


Fig. 6. Threading the Screws

avail itself of the power developed is St. Louis, located 135 miles from Keokuk. The street railway and electric light companies in that city have already contracted for 60,000 horsepower.

* * *

TEST ON SECTIONAL FIREBOX BOILERS

An interesting demonstration of a new type of boiler was recently made at Coatesville, Pa., under the direction of Dr. W. F. M. Goss, dean of the College of Engineering, at the University of Illinois. Two full sized locomotive boilers, designed for high-speed passenger service, were each subjected to severe low water tests. Both boilers were identical in size and design except that one was provided with a Jacobs-Shupert sectional firebox built by the Jacobs-Shupert Firebox Co., while the other had an ordinary radial stay firebox. The observations were taken from a safe location 200 feet away from the boilers. After the boilers were in normal operation, the feed water supply was shut off, the crown sheet and other portions of the heating surface being still subjected to the heat of the fire. The boiler having the Jacobs-Shupert sectional firebox was tested under these severe conditions for 55 minutes without failure, notwithstanding the fact that the level of the water fell to a point more than 25 inches below the crown sheet. The ordinary stay boiler exploded after the test had continued for 23 minutes, the water level having fallen to 14½ inches below the crown sheet. The crown sheet and the stays which hold it in place, having become highly heated, pulled away from each other and released the pressure in the boiler. The damage to the boiler was such as to make entire reconstruction necessary.

EFFICIENCY OF WORM GEARING FOR AUTOMOBILE TRANSMISSION*

RECORDS OF A NUMBER OF TESTS MADE ON VARIOUS TYPES OF WORM GEARING

The investigations recorded in the following were made at the plant of the Brown & Sharpe Mfg. Co., Providence, R. I., for the purpose of determining the efficiency of three types of

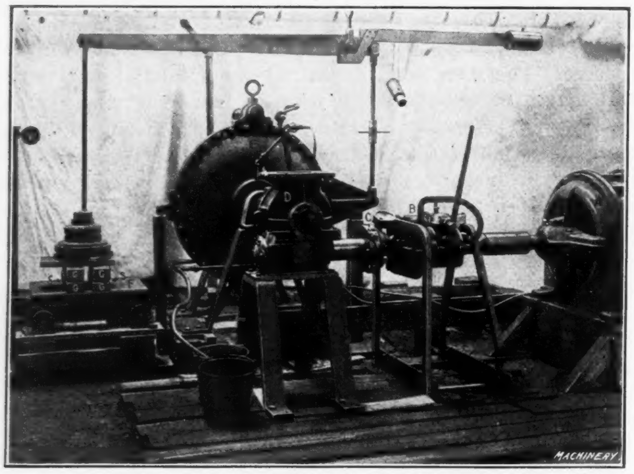


Fig. 1. Arrangement Used for Testing Efficiency of Worm and Gear Drives

worm gearing for use in an automobile transmission system, and the heating effect due to continuous running. The power for these tests was obtained from a 50 H. P. induction motor, running at approximately 870 R. P. M. at full load. Between

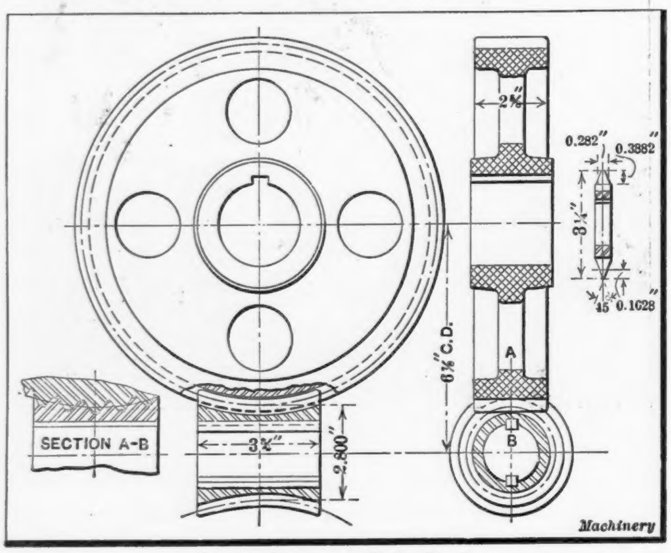


Fig. 2. Worm-gear Drive No. 1

the motor and the worm-gear case was placed an automobile transmission-gear case to enable tests to be made at two lower speeds. Between this and the worm-gear case was placed a transmission dynamometer designed by the author. (See

Fig. 3. Section through Teeth, Drive No. 2   Fig. 4. Section through Teeth, Drive No. 3

MACHINERY, June, 1909, engineering edition, for description of this device.) An Alden brake was used to absorb and measure the power transmitted by the gears under test. The apparatus is shown in Fig. 1 as arranged for testing worm gears; *A* is the motor, *B* the automobile transmission-gear case, *C* the transmission dynamometer, *D* the case containing the worm gear under test, *E* the Alden brake, and *F* the platform scale which measured the load on the Alden brake.

The apparatus was so arranged that as the load was imposed, the weight on the platform scale was removed, and all vibration of the scale beam was eliminated by interposing springs *S* between the blocks *G* which sustained the weight

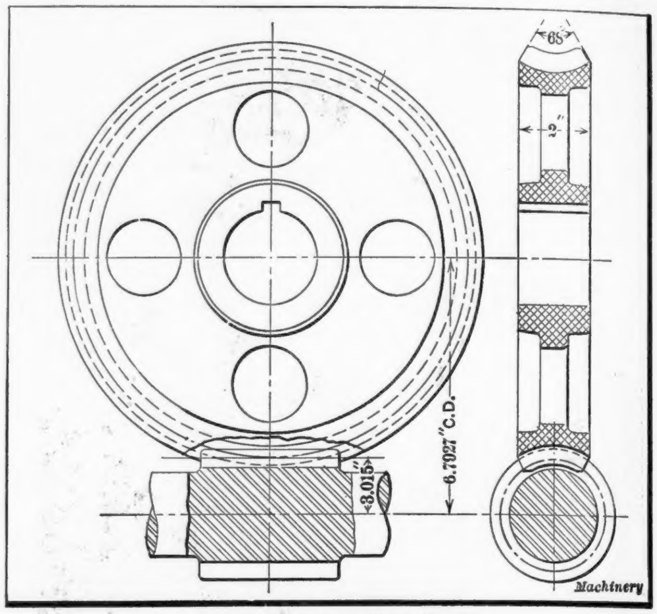


Fig. 5. Worm-gear Drive No. 3

on the scale, and also by suspending by a wire from the weight at the end of the scale beam a plate which dipped into a pail of oil, thus acting as an efficient dashpot. It was found possible by careful manipulation to maintain a steady and easily read load on both the transmission and absorption instruments.

With this arrangement of the transmission dynamometer and brake, runs were made at various loads, and the torques corresponding to horsepowers per 100 R. P. M. marked on the dial

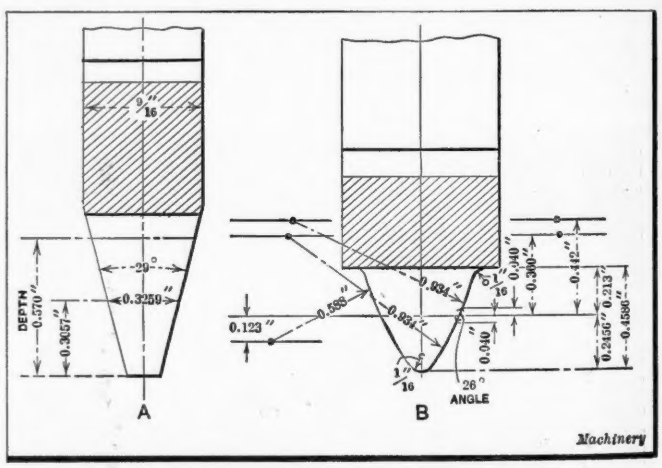


Fig. 6. A, Cutter for Gear No. 2; B, Cutter for Gear No. 3

of the transmission instrument, corresponding to similar loads as indicated on the brake. It is evident that by this method of comparison the two instruments must check each other exactly. A thermometer placed in the oil-well at the back of the worm-gear case *D* indicated the temperature of the oil, and another thermometer placed on the wall near the apparatus indicated the room temperature. The oil employed to lubricate the gears was one intended for use with superheated steam, having a specific gravity of 26 Baumé, a flash point of 625 degrees F., and a viscosity at 212 degrees F. of from 260 to 265. The case contained about five quarts of the oil.

In all the trials the worm was located underneath the gear.

* Abstract of a paper by Prof. Wm. H. Kenerson, of Providence, R. I., presented before the American Society of Mechanical Engineers.

Fig. 7 shows a section through the gear case. As indicated, both shafts are mounted on ball bearings and end-thrust ball bearings take care of the thrust on the worm and worm-wheel. All the worms were made of machine steel, casehardened, and the worm-wheels of phosphor-bronze.

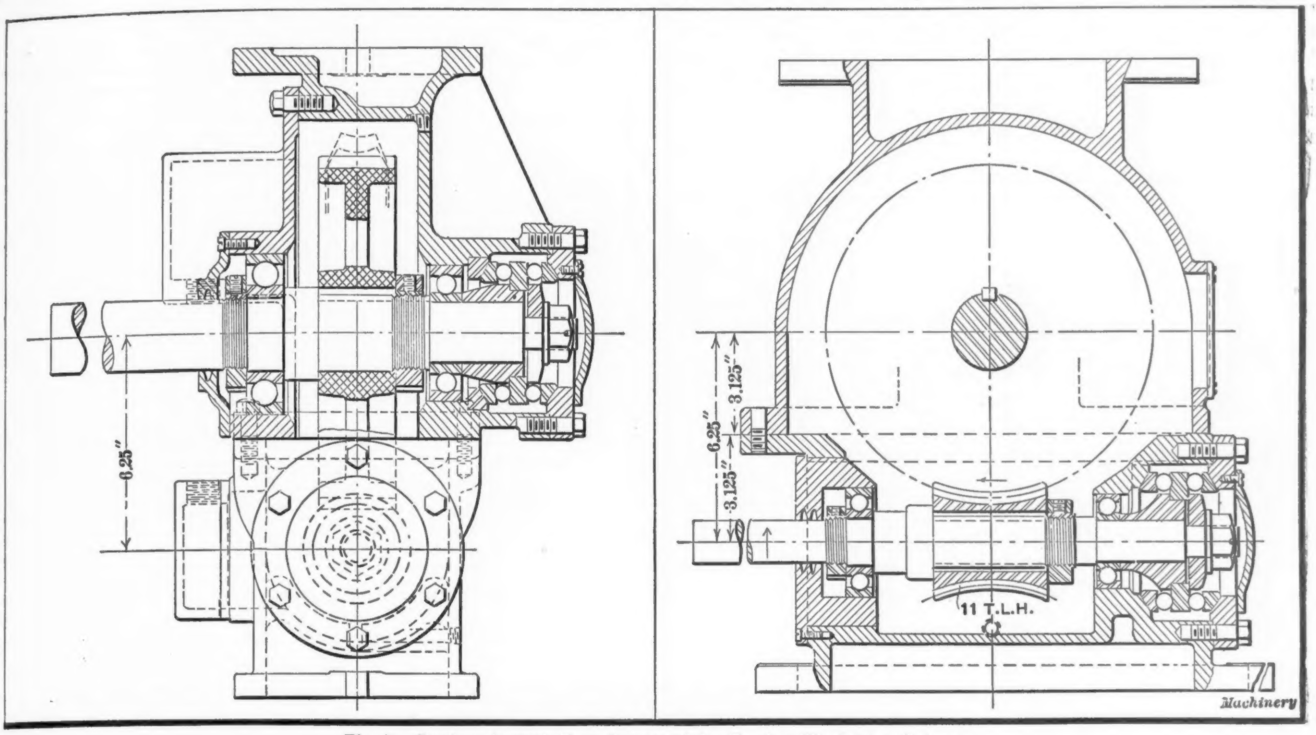


Fig. 7. Section through Gear Case used for Testing Worm-gear Drives

The first worm and wheel tested are shown in Fig. 8, and are similar to those used for driving the spindle on the Brown and Sharpe automatic spur gear machines. This pair of gears is an unusual case of the worm and worm-wheel. The smaller gear is hobbed with a hob of the size of the larger gear, thus making possible adjustment of the larger gear, which would not otherwise be the case. While in appearance this gear resembles a Hindley worm, it is not of this type. The smaller gear will be called the worm and the larger, the worm-wheel, in the following description. Fig. 2 gives the dimensions of the worm and gear shown in Fig. 8. The specifications for this pair of worm and worm-wheel are as follows: worm-wheel, phosphor-bronze; No. of teeth, 43 left hand; pitch diameter, 10.95; outside diameter, 11.28; circular pitch, 0.800; angle of teeth with axis, 45 degrees; normal circular pitch, 0.5657; pitch of cutter, 5.553; addendum, 0.1628 (not standard); thickness of tooth, 0.282; whole depth, 0.3882; included angle of cutter, 45 degrees. The worm-wheel was cut with the cutter shown, and the shape of the teeth on a section through the worm and worm-wheel, parallel to the axis of the worm, is also shown.

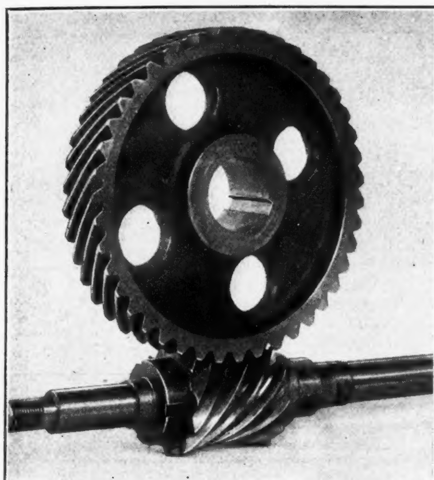


Fig. 8. Worm-gear Drive No. 1

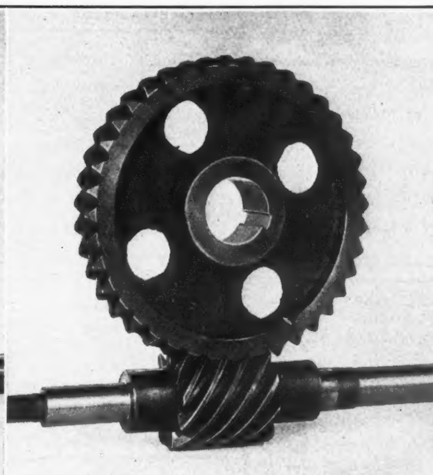


Fig. 9. Worm-gear Drive No. 2

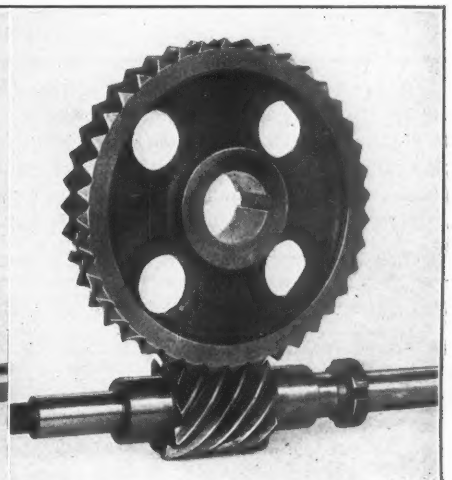


Fig. 10. Worm-gear Drive No. 3

TABLE I. EFFICIENCY TEST OF NO. 2 WORM-GEAR WHEN ON DIRECT SPEED

R.P.M. Motor	R.P.M. Worm	R.P.M. Worm-gear	Speed of Worm in Feet per Min.	Initial Load	Reading on Scale	Load on Brake 315-foot Radius	Brake H.P. per 100 R.P.M.	Total Brake H.P.	Total Transmission Dynamometer H.P.	Efficiency of Worm-gears	Transmission Dynamometer Reading				Temperature at End of Test		Time		Duration, Minutes
											1	2	3	Av.	Oil	Room	Start	Finish	
875	875	196.9	690.7	104	55	49	24.5	48.24	49.26	97.9	5.6	5.65	5.65	5.63	268	65	10:14	10:20	6
873	873	196.4	689.1	104	60	44	22.0	43.22	44.35	97.5	5.1	5.05	5.1	5.08	273	65	10:20	10:25	5
880	880	198.0	694.6	104	65	39	19.5	38.61	40.92	94.4	4.7	4.65	4.6	4 65	276	66	10:25	10:30	5
880	880	198.0	694.6	104	70	34	17.0	33.66	36.26	92.8	4.15	4.1	4.1	4.12	275	66	10:30	10:33	3
883	883	198.7	697.0	104	75	29	14.5	28.81	31.17	92.4	3.55	3.55	3.5	3.53	273	66	10:33	10:37	4

The general appearance of pairs Nos. 2 and 3 are shown in Figs. 9 and 10, and the dimensions in Fig. 5. The difference between gears Nos. 2 and 3 is principally one of shape of the worm threads. This difference is clearly brought out in the

sections of the worm and wheel shown in Figs. 3 and 4. The specifications for the No. 3 worm and worm-wheel are as follows: Worm-wheel, phosphor-bronze; number of teeth, 40; pitch diameter, 10.5704; throat diameter, 10.9964; circular pitch, 0.8302; angle of teeth with axis, 38 degrees 16 minutes; normal circular pitch, 0.6518; pitch of cutter, 4.8196; addendum, 0.213; thickness of tooth, 0.3568; whole depth, 0.4586. Worm: Aurora steel, casehardened; number of teeth, 9; pitch diameter, 3.015; outside diameter, 3.441; circular pitch, 1.0524; angle of teeth with axis, 51 degrees 44 minutes; thickness of tooth, 0.295; lead, 7.4719; ratio of wheel to worm, 40 to 9.

TABLE II. AVERAGE EFFICIENCIES OF WORM AND GEAR NO. 1

Speed	R. P. M.		H. P.		Temperature, Degrees F.		Efficiency
	Worm	Worm-Wheel	Input	Output	Oil	Room	
First Speed	254.2	65.03	26.18	24.06	206	73	91.9
	254.6	65.13	24.75	22.47	217	73	90.8
	254.5	65.11	22.98	20.81	225	73	90.5
	255.1	65.25	21.17	19.25	228	73	90.9
	255.3	65.30	19.56	17.63	232	73	90.1
	255.7	65.41	17.76	16.02	233	74	90.2
	255.9	65.48	16.00	14.41	233	74	90.1
	256.3	65.60	14.31	12.79	233	74	89.4
	256.5	65.62	12.37	11.15	231	74	90.2
	256.8	65.69	10.55	9.53	229	74	90.2
Second Speed	545.2	139.5	43.48	41.16	178	73	94.8
	546.9	139.9	40.54	37.78	207	70	93.0
	547.8	140.1	36.88	34.33	214	70	93.2
	548.8	140.4	33.47	30.89	217	70	92.3
	550.2	140.7	29.76	27.44	218	70	92.3
	550.5	140.8	26.01	23.94	218	71	91.3
	551.1	141.0	22.22	20.45	217	71	92.0
Direct	859.5	219.8	66.43	64.86	178	69	97.0
	864.5	221.1	62.80	50.71	201	70	94.9
	871.0	222.8	59.23	54.60	214	70	92.2
	874.5	223.7	54.22	49.22	224	70	90.8
	878.0	224.6	48.60	43.80	230	70	90.1
	882.0	225.6	42.25	38.36	233	70	90.8
	884.0	226.1	36.24	32.79	237	71	90.5

The shape of the teeth on the worm in Fig. 3 was produced with a cutter, the included angle of which was 29 degrees, and the depth of tooth 0.570 inch. This depth was based on the axial pitch, whereas the usual method on multiple worms is to base the depth on the normal pitch. The object in using this cutter was to obtain as many teeth as possible in contact at one time and also a shape that could be ground with a straight-sided emery wheel. The teeth of the worm in Fig. 4 were cut with a cutter shaped as shown at *B* in Fig. 6, which is an arbitrary shape made to produce the greatest effective breadth possible.

TABLE III. AVERAGE EFFICIENCIES OF WORM AND GEAR NO. 2

Speed	R. P. M.		H. P.		Temperature, Degrees F.		Efficiency
	Worm	Worm-wheel	Input	Output	Oil	Room	
First Speed	254.7	57.32	19.26	18.34	164	69	95.3
	254.7	57.32	17.99	16.91	160	69	94.1
	254.5	57.25	16.73	15.46	162	68	92.5
	254.3	57.22	15.08	14.02	142	69	93.1
	255.1	57.39	13.52	12.63	159	69	93.5
	254.9	57.35	12.14	11.18	160	69	92.2
	254.8	57.34	10.69	9.75	160	69	91.4
Second Speed	544.2	122.4	36.95	36.11	178	70	97.7
	545.0	122.6	34.61	33.10	184	70	95.6
	546.7	123.0	32.09	30.14	188	70	93.9
	548.4	123.4	28.90	27.15	187	70	93.9
	549.0	123.5	25.80	24.08	186	71	93.3
	549.6	123.7	22.59	21.03	163	70	93.1
	551.0	124.0	19.12	17.98	163	70	94.0
Direct	873.5	196.5	49.35	48.14	265	66	97.5
	875.0	196.9	44.50	43.30	256	65	97.3
	878.0	197.5	40.40	38.50	260	66	95.2
	881.0	198.2	36.40	33.70	261	66	92.4
	883.4	198.8	30.73	28.84	262	66	93.8

In conducting the trials, the load was maintained at the desired point by one observer who adjusted the brake. Readings were then taken on the transmission instrument by two independent observers. The speed of the motor was observed in each case, and from this, knowing the gear ratio, all the other speeds were easily computed. Temperatures were taken immediately following each series of observations. For purposes of comparison, a series of trials was also run on a pair of bevel gears. The specifications for this bevel gear and pinion are as follows: Driving pinion, 5 per cent nickel steel, casehardened; pitch, 5; number of teeth, 14; angle of edge, 15 degrees 4 minutes; angle of face, 71 degrees 5 minutes; outside diameter, 3.3359. Driving gear, 5 per cent nickel steel, casehardened; pitch, 5; number of teeth, 52; angle of edge, 74 degrees 56 minutes; angle of face, 13 degrees 47 minutes; outside diameter, 10.4627.

TABLE IV. AVERAGE EFFICIENCIES OF WORM AND GEAR NO 3

Speed	R. P. M.		H. P.		Temperature, Degrees F.		Efficiency
	Worm	Worm-wheel	Input	Output	Oil	Room	
First Speed	254.1	57.19	18.75	18.30	136	79	95.5
	254.8	57.33	16.54	15.48	144	79	93.1
	255.0	57.38	13.75	12.62	149	79	91.8
	255.4	57.47	10.80	9.77	150	79	90.5
	255.6	57.52	7.38	6.90	149	79	93.6
Second Speed	543.2	122.2	38.59	36.06	204	77	93.4
	543.8	122.4	35.36	33.04	215	77	92.4
	544.8	122.6	33.12	30.03	219	77	90.7
	545.8	122.8	29.82	27.02	221	77	90.6
	546.5	123.0	26.70	23.98	222	78	89.8
	547.2	123.2	23.56	20.95	222	78	88.9
	548.3	123.4	20.02	17.89	221	78	89.4
Direct	866.0	194.8	49.95	47.72	215	77	95.5
	868.2	195.3	45.68	42.98	223	77	94.1
	870.8	195.9	41.20	38.20	228	77	92.7
	874.0	196.7	36.88	33.45	230	77	90.6
	876.0	197.1	31.45	28.60	230	78	90.9
	878.8	197.7	26.45	23.73	229	78	89.7

TABLE V. AVERAGE EFFICIENCIES OF BEVEL GEARS

Speed	R. P. M.		H. P.		Temperature, Degrees F.		Efficiency
	Pinion	Gear	Input	Output	Oil	Room	
First Speed	254.2	68.43	20.92	20.19	....	70	96.6
	254.5	68.51	17.50	16.78	....	70	95.9
	256.1	68.95	14.54	13.44	....	69	92.4
	256.5	69.05	10.95	10.01	....	70	91.4
Second Speed	541.8	145.0	39.64	39.37	....	67	99.3
	544.1	146.4	33.43	32.22	....	67	96.4
	545.7	146.9	26.25	24.98	....	67	95.2
	548.5	147.6	18.75	17.72	....	67	94.5
Direct	872.0	234.7	52.05	51.63	....	70	99.2
	878.6	236.6	42.09	40.22	....	70	95.5
	884.4	238.2	30.40	28.58	132	79	94.0

Table I is a record of one set of observations, typical of the series. Tables II, III, IV and V summarize the results of all the trials, and the curves of Fig. 11 show the average efficiency of the different gears at the various loads and speeds. In conjunction with the efficiency trials, a series of runs was made to determine the heating effect due to continuous running. In these trials, which were in effect endurance tests, a constant load was transmitted through the gearing, and the temperature of the oil in the gear case and the temperature of the room noted at frequent intervals. From these observations it was found that at the beginning of the run the oil temperature rose rapidly and somewhat irregularly. As the run continued, however, the rise became much more gradual and regular. In the runs where the smaller amounts of power were transmitted a point was reached where the temperature remained constant. This indicated that radiation was sufficient to carry away the heat due to power lost through friction in the gearing, or in other words, that the gears would run indefinitely at that load. The heat curves of the No. 1 worm and gear are shown in Fig. 12.

The higher loads indicated were abnormal for the gears under consideration, and would not occur in any use to which the gears would normally be put. The fact that these trials continued for from 60 to 80 minutes without failure indicates that the structure is both strong and enduring and that, should such temperatures be reached for any accidental reason, the gears would not be destroyed. The result of the trials was of particular interest because of the very high efficiency and carrying capacity of the gears tested.

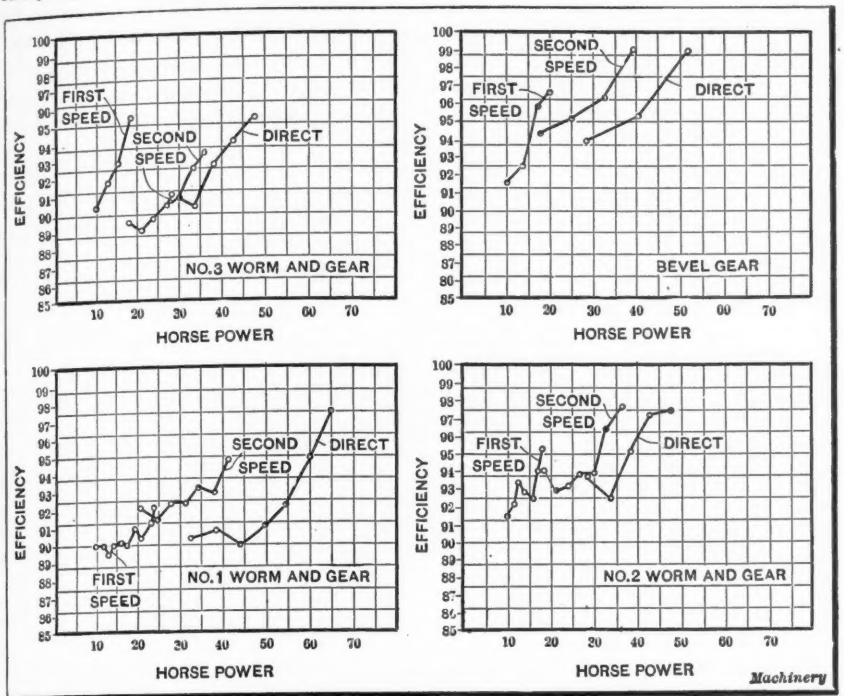


Fig. 11. Efficiency Curves at Various Loads and Speeds

Every possible precaution was taken to secure accuracy in the results, and the high degree of accuracy obtained is due largely to the skill and care of Mr. B. F. Waterman of the Brown & Sharpe Mfg. Co., under whose personal supervision the apparatus was erected and all the trials were conducted.

* * *

A new development in pneumatic tires of a revolutionary nature promises to make considerable improvement in what now is the weakest member of the automobile. The ordinary pneumatic tire is inflated with air, compressed to a pressure of about eighty pounds per square inch. In the new tire the

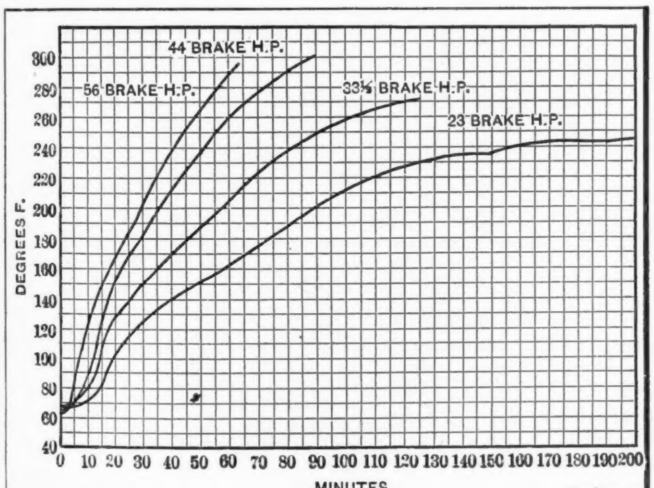


Fig. 12. Heat Curves for No. 1 Worm and Gear

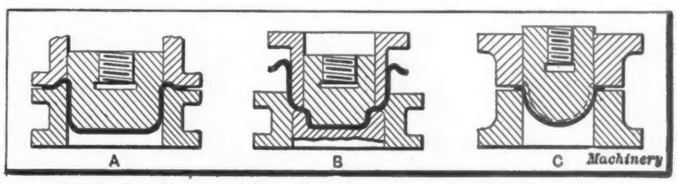
condition of air pressure is reversed, the air being pumped out, leaving the internal pressure at about eight pounds absolute. The external pressure, of course, tends to collapse the walls, which are so shaped that the internal cross-section assumed is a flattened ellipse with the long axis vertical. Load on the tire tends to separate the sides and press them outward against the external or atmospheric pressure. Thus the tire rides on external air pressure instead of internal pressure, as in the common type.

PREVENTION OF WRINKLES IN DRAWN WORK

The formation of wrinkles in drawing operations is a source of great trouble, and there are many pieces of drawn work which could be performed in a single operation were it not for the wrinkles that would inevitably appear. In drawing operations, the tendency to wrinkle starts with the first contact of the punch upon the metal.

The usual method of preventing wrinkles is to provide the punch with a blank-holder which is operated by springs of sufficient tension to allow the metal to be pulled from beneath it for drawing, but maintaining pressure enough to keep the metal free from wrinkles. At *A*, in the accompanying illustration, reproduced from the *Zeitschrift für Werkzeugmaschinen und Werkzeuge*, appears a section of a simple drawing die in which it will be noticed that the die is provided with a raised ridge around its opening, the blank-holder having a corresponding depression. Consequently, the sheet metal being drawn is pulled over this ridge, and as the space between the blank-holder and the top of the ridge is purposely made slightly less than the thickness of the metal, it will be seen that as the stock passes through this opening any wrinkles are "ironed out." At *B*, the shell from the dies at *A* is shown undergoing a second operation.

For strength and protection in hardening, as well as to facilitate the drawing operation, the ridge is provided with a fillet where it joins the flat surface of the die. It is obvious that the addition of this ridge to the drawing die occasions a little extra work in the die-making, but this work is offset by the fact that the blank-holder and upper surface of the drawing die do not have to be ground perfectly smooth and parallel, as is ordinarily required.



A Method of Drawing Sheet Metal by Means of which Wrinkling of the Stock is avoided

The size of the ridge around the die should be in proportion to the diameter of the shell. A shell 4 inches in diameter is most easily drawn with a die having a ridge of 7/16 inch radius. For a shell of 8 inches diameter the radius of the ridge should be ½ inch. For a shell 12 inches in diameter the radius of the ridge should be ⅝ inch. For a shell 16 inches in diameter the radius of the ridge should be ¾ inch, and a shell 20 inches in diameter would require a ridge having a radius of 1 inch.

It is obvious that the completed shell will have a ridge left at the edge. On work which is to be wired or for work on which the edge is to be turned over, this additional ridge is no detriment as it can be made use of directly. Moreover, if a succeeding operation is to follow, deepening the shell slightly, this ridge will provide the surplus metal required. This point is illustrated at *C*. In other cases, the extra metal left at the edge may be removed when the shell is trimmed. It is claimed that this improvement in drawing dies is being employed with success. By its use, wrinkles are absolutely prevented, and, moreover, the drawing operation puts less stress upon the metal.

* * *

The J. N. Lapointe Co., Marlboro, Mass., maker of broaching machinery, recommends the use of the following compounds when broaching steel: 2½ pounds of soda-ash; 3 gallons of mineral lard oil; and 50 gallons of water. Mix the soda-ash and the lard oil with 10 gallons of water, and add the other 40 gallons afterward.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY.

CENTERING DROP-FORGED CRANKSHAFTS

The usual method of centering drop-forged crankshafts for the lathe, *viz.*, by marking off on centers and surface plate is very slow when a great number of crankshafts are to be centered. The method described in the following is considered by the writer to be an improvement upon previous methods.

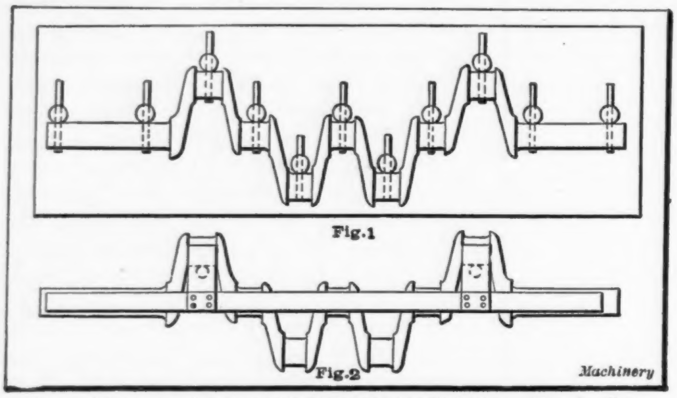


Fig. 1. Plate used for Correcting Warped Crankshafts. Fig. 2. Gage for Cutting off Crankshaft to Right Length

The drop-forgings are first tested for alignment, as they often warp slightly in hardening. This warping should be corrected by the aid of a plate fitted with pegs, as shown in Figs. 1 and 3. The pegs are a good fit in the holes in the plate and correspond to the correct outline of the crankshaft. Each peg has a piece of steel rod projecting through it at each side and resting on the surface of the plate. The drop-forging is placed on these projecting rods and is straightened until each journal and throw has a reasonably close contact with them, the variations allowed depending upon the amount of material left for machining in the drop-forging. The small steel rods keep the webs of the crank from touching the plate, while the vertical pegs give the correct alignment to the throws and journals in planes at right angles to the plate.

The ends are next sawed off to within ¼ inch of the finished length; a simple templet, as shown in Fig. 2, is used for marking this length correctly. The crank is now ready to have the centers put in. This is done on a sensitive drilling machine, the column of which is provided with a pivot carrying the centering jig shown in Fig. 4. This jig consists of a

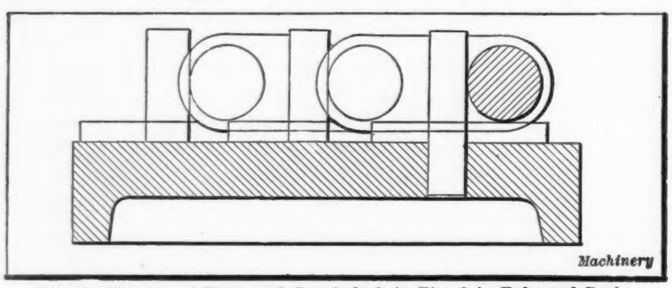


Fig. 3. Section of Plate and Crankshaft in Fig. 1 in Enlarged Scale

stiff cast base or bar, pivoted at the center, with a T-slot along its full length. At each end a bracket is mounted, the position of which is adjustable to suit the length of the crankshaft. These brackets are fitted with bushings to suit the diameter of the center drill. One end of the bushing is enlarged to form a cap for the end of the crankshaft. The hole in this cap should be larger in diameter than the diameter of the largest drop-forging likely to be used. The ends of the crankshaft are held in this cap by means of four set-screws.

Setting gages are used as indicated in Fig. 4. These are bolted in the T-slot at the correct position for each throw and journal. These gages are made of thin spring-steel blades of suitable length, allowance being made for the material to be left for machining. They can be easily changed for different sizes of crankshafts and are cheap to make.

One end of the crankshaft is now placed in the cap at the bottom. The top bracket is raised to allow the crankshaft to enter into its cap, and then the crankshaft is secured in the caps by the set-screws. When clamped it is turned and tried against the steel blades, the set-screws being adjusted until the best average position is obtained. Then the center is drilled at one end, the jig swiveled around, and the center drilled at the other end. It would be a still further improvement to mount the jig horizontally and use a simple drill head at each end of the crankshaft. In this case, a swiveling jig would not be required and both centers could be drilled at the same time.

It will be found that in addition to having obtained a better and quicker method of centering than is afforded by the usual

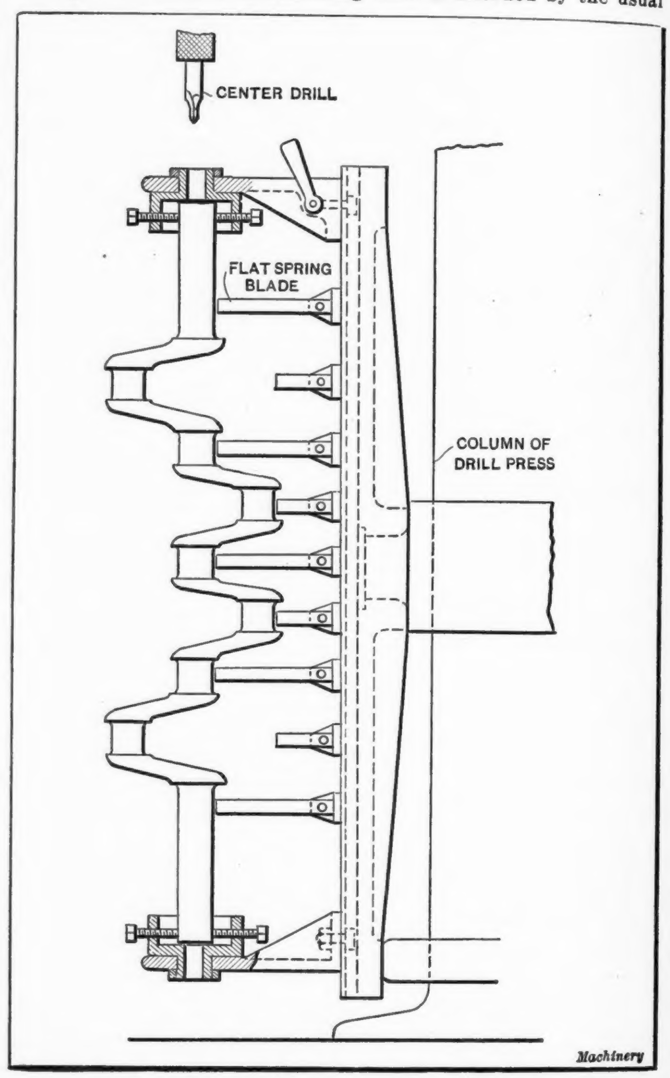


Fig. 4. Centering the Crankshaft in the Drill Press

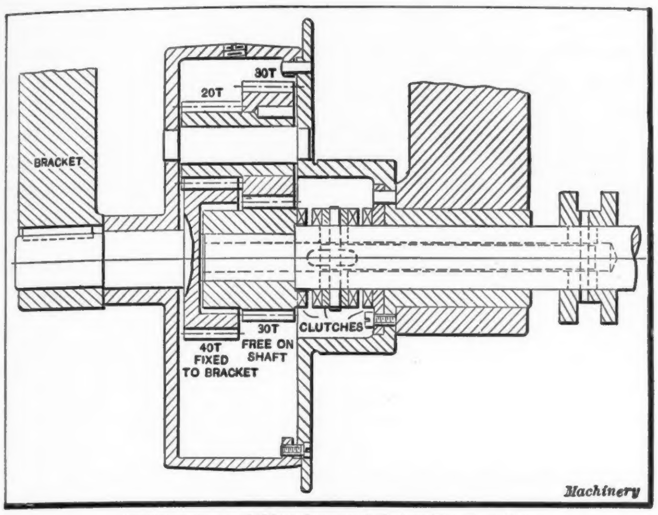
marking-off method, there will be fewer broken center drills, owing to the fact that the crank is held steadily and its weight is not taken by the weak point of the drill. G. R.

PLANETARY GEARING—OIL-PUMP TROUBLES

A writer in the May number of MACHINERY mentions an instance of the successful employment of planetary or differential gearing as a speed reducing mechanism. That gearing of this type may be successful at low speeds such as cited (120 revolutions per minute) is, no doubt, possible, but when the speed rises to say 500 revolutions per minute, the experience of the present writer goes to show that it ought not to be employed. In one case a number of machines furnished by a high-class concern were driven in one direction by a direct drive. To obtain a reverse drive certain clutches were used to throw into action a train of epicyclic gears. All gears were regular spur gears, no in-

ternal gear being used. The accompanying illustration shows the arrangement of the gears. All the gears ran in oil, but, nevertheless, the noise, right from the beginning, was more than normal, and it increased the longer the machines were used. Finally an examination disclosed that the teeth of some of the gears had worn so badly that they had broken off; the wear was also very unequal. It was assumed that the gears were too weak, and, hence, they were replaced by carefully made hardened steel gears. These, however, were so noisy that it was finally decided to eliminate the planetary gearing and use a reverse countershaft.

There seems, at first, to be no good reason why planetary gearing should cause any more noise or wear than ordinary gearing, but that some reason exists is certain. The writer believes that the trouble is due to the fact that the resultant of the various forces is a constantly changing one, due to



Arrangement of Clutches and Epicyclic Gearing

the varying positions of the planetary gears in their motion. Sometimes the forces will tend mainly to draw the centers closer together; at other times there will be forces tending to force them further apart. Hence, there is a constant sliding movement between the teeth of the meshing gears which accounts both for the excessive wear and the noise, particularly at high speeds. In some cases the trouble may be due to the pull of the belt and the pressure from the gears being in different planes, thus tending to tilt the gears, the amount of this tilting action varying according to the varying direction of the resultant force. As the various shafts and bearings wear, this creeping between the teeth with accompanying noise and wear, will become intensified.

The variations in the resultant force will not be so great when three, four, or more planetary gears are used, but then the manufacturing difficulties are greatly increased; in fact, so many factors require attention as regards accuracy, as to make it almost impossible to insure that each planetary gear would bear its fair share of the duty. Take the case of four planetary gears as an example. Here we have the possible inaccuracies of four radial distances and of the four center-to-center distances between the planetary gears themselves; then there are ten gear diameters to be taken into account, the errors in which may or may not balance each other. Furthermore, each of the double planetary pinions must have their teeth exactly in the same relation on each gear. In fact, the only possible way to get anything like an equal load on each gear is to allow plenty of freedom in all running parts, but this would tend neither to freedom from noise nor from wear.

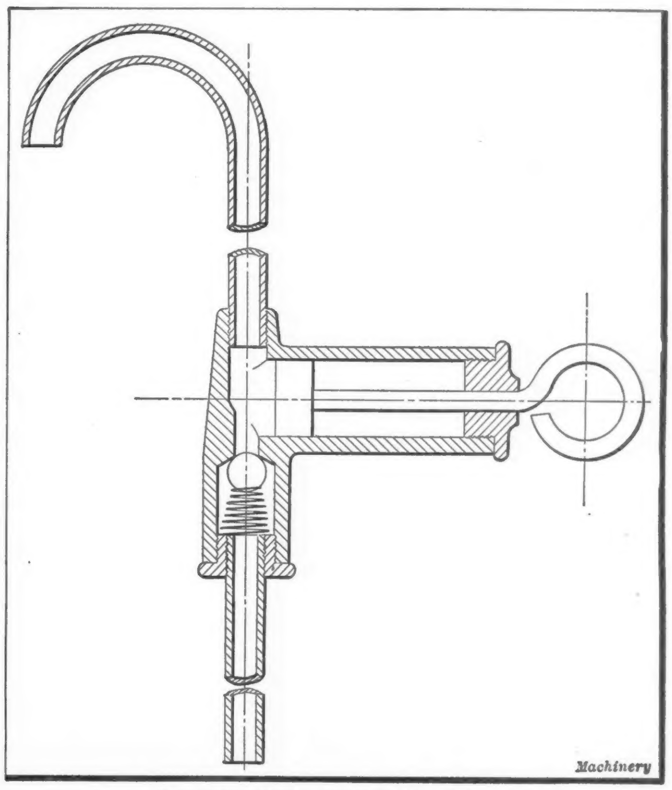
A little incident which occurred in connection with the same machines affords a good example of how small points are apt to be neglected. After the machines were put into operation with a reverse countershaft, it was found that the oil-pump failed to act on the reverse drive, owing to the change in direction of the rotation of the driving pulley. It was, however, necessary to supply oil while the machine was running in the reverse direction also. One remedy, of course, would have been to replace the pump by a reversible one. However, one of the operators conceived the idea of replacing the pump pulley by two pulleys side by side, each bearing a bicycle free-wheel or coaster fixed to drive in opposite directions. Two belts, one open and one crossed, were used to drive the pulleys. Then, no matter which way the machine was running, one of the free-wheels would drive the pump.

E. P. Ciclick

DEVICE FOR EMPTYING OIL DRIP-CUPS

On advertising page 177, in the July number of Machinery, the following "Don't" for machinists is given: "Don't work on any machine if the countershaft hangers are loose." While the writer does not know of any case where anyone has been hurt by the countershaft falling down, he does know of cases where the oil drip-cups have come down. These drip-cups must be emptied at intervals, and, apparently, they are not always put back in position as tightly as they ought to be. Perhaps, also, the looseness is produced by their being removed and put back again at frequent intervals. To empty them, it is necessary to go up on a ladder, which is, in itself, dangerous.

The accompanying engraving shows a device by means of which the oil drip-cups can be emptied without removing them, and much more rapidly than by the ordinary methods. This device the writer has seen in use "on the other side of the pond." The device consists of a long length of piping projecting from the top of the main body, and having a bent or hooked end. The piping used is ⅜-inch gas pipe. At the bottom end a short straight length of piping projects. The ball in the valve shown is held in position by a light spring, just strong enough to support its weight. To the right is a projection containing a pump piston.



A Convenient Device for Emptying Drip-cups

The manner in which this device is used is as follows: The man emptying the oil drip-cups goes around with this device and a pail. To empty the oil drippers he simply hooks the pipe end onto the dripper and pulls out the piston once, so as to start a syphon action; after this the oil will empty into the pail very quickly. The ball valve stops the air from being drawn into the cylindrical section when the piston is drawn out, but it does not stop the oil from flowing past it when it comes down the long pipe. This device does away with the necessity of loosening the drippers; the action is quick, and no danger is attached to its use, as when a ladder has to be employed.

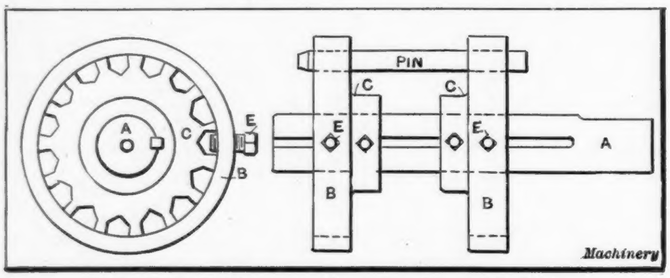
Richard W. Dickinson

Pawtucket, R. I.

DEVICE FOR SIZING PRESSURE PINS

Many mechanics, in making combination cutting and drawing dies for single-acting punch presses, have undoubtedly experienced difficulties with trying to make pressure pins of an equal length. With the aid of the device or mandrel shown in the accompanying engraving, the old cut-and-try methods are entirely done away with, and a complete set of pins can be faced at both ends to equal length at one setting. The mandrel shown has a maximum capacity for fifteen ½-inch pins.

In the engraving, the mandrel *A* is made of tool steel, and has a flat milled for the set-screw of the driver. The collars

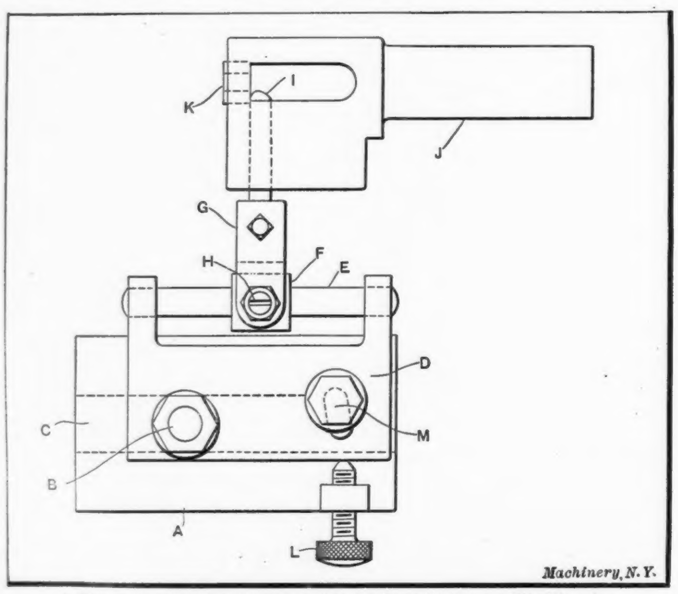


Mandrel for Holding Sets of Pressure Pins while Sizing

C are made of cast iron and have slots milled in them for the pins. They are fitted to the mandrel *A* by keys to insure rigidity, and the slots are milled after the collars are fitted to the arbor, so that the grooves will line up. The machine steel rings *B* carry set-screws *E*, which latter should be quite smooth and flat on the ends, so as not to mar the pins. Rings *B* are shrunk onto the collars. When using this device, it is advisable to keep the collars as close to the ends of the pins as possible, to insure good support. Light cuts should be taken, and a fine cross-feed used. A grinder is to be preferred to a lathe when such a machine is available. A. J. B.

A TAPER TURNING TOOL FOR THE AUTOMATIC SCREW MACHINE

The accompanying illustration shows a taper turning tool used in the automatic screw machine for turning taper pins. This tool, however, cannot be used where it is necessary to revolve the turret, and the feeding finger alone is used to govern the length of the stock. This device consists mainly of a base *A* held on the cross-slide, by a bolt and nut *B*, the



A Taper Turning Tool used in the Automatic Screw Machine for Turning Taper Pieces

base being located by the tongue *C*, which fits in the slot in the cross-slide. Attached to the base *A* is a member *D* which swivels on the bolt *B*. Driven into the member *D* is a pin *E* on which the bushing *F* slides. The tool-holder *G* is cut out to fit over the bushing *F*, and is held to it by two cone-pointed screws *H*. This tool-holder *G* holds the turning tool *I*, which slides freely in the member *J* held in the turret. A bushing *K* which has a hole in it of the same size as the diameter of the stock to be turned, is driven into the front end of the member *J* to support the work.

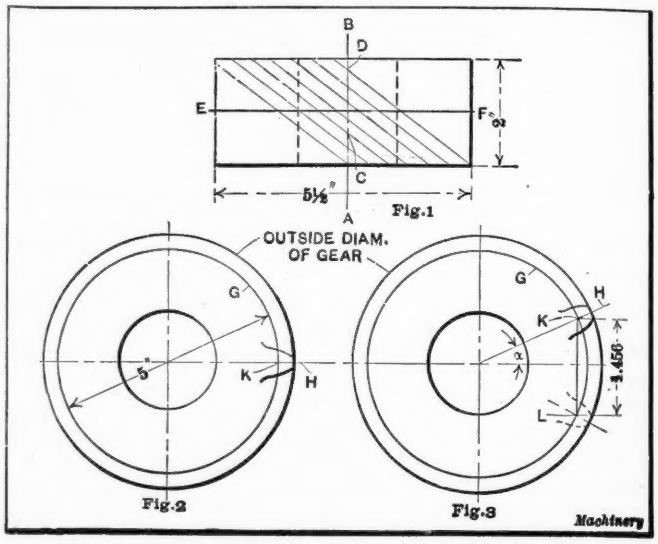
In operation, the cross-slide is held stationary, the turret alone advancing. The taper on the work is governed by swinging the member *D* to the desired angle, and when in the desired position, it is stopped by the knurled screw *L*, and clamped by the cap-screw *M*. A slot is cut in the swinging member *D* so that it can be adjusted to various angles. When the tool is set correctly, the feeding device is then set so that it will feed the stock out to the desired length. When the pin has been turned it is cut off by a circular tool held on the rear cross-slide. While the pins cut off vary slightly in length, they are close enough for most purposes.

Detroit, Mich. DAVID MELVILLE

DETERMINING THE LEAD OF SPIRAL GEARS

A spiral gear of 5½-inch diameter and 2-inch face was sent to the shop with the order, "Make a duplicate at once as something has happened to this one." This last assertion no one was inclined to dispute, as there was not one uninjured tooth on the gear, which, moreover, was broken into two pieces. The first requirement, in order to be able to duplicate the gear, was to find the lead of the spiral.

The usual method, to scribe a line *AB*, Fig. 1, parallel with the axis of the gear, measure with a height gage the distance between two intersections of tooth edges, as *CD*, multiply by



Figs. 1 to 3. Method used for Determining Lead of Spiral Gear

the number of teeth in the gear, and divide by the number of tooth spaces between *C* and *D*, is not always entirely accurate in practice, although admirable in theory. In this case, this method could not be employed as the gear was so injured that no place could be found where a line so drawn would cut the edges of two teeth.

The man to whom the job was given drew a line *EF*, Fig. 1, at right angles to the axis and midway between the end faces of the gear. He then tied the two halves together, inserted a size plug in the hole in order to obtain a center, and with dividers scribed a circle *G* as shown in Fig. 2 on each end of the gear. This circle was 5 inches in diameter. He then put the gear on an arbor clamped in a V-groove in the vertical face of a cube-shaped piece which rested on the surface plate. If this appliance had not been available, he could have put the arbor between the centers of a lathe, laying a parallel across the shears as a base from which to measure.

Setting the height gage to the center height of the arbor and using a lens to insure all possible accuracy, he scribed in the center of each end of one tooth a radial line as shown at *H* in Fig. 2, choosing a tooth which showed line *EF* on the top of it; then, turning the gear so that the intersection of *EF* and the center line on the top of the tooth were in a horizontal plane passing through the arbor center, he measured with the height gage to the point *K* on each end of the tooth. The difference between these measurements was 1.456 inch which represented the advance of each tooth in the width of the gear

face (2 inches). This advance is not 1.456 inch on the circumference of the circle but is the chordal distance *KL*, Fig. 3. Now the length of *KL* divided by the diameter of the circle *G* equals the sine of angle α.

$$\frac{1.456}{5} = 0.2912; \text{ hence } \alpha = 16 \text{ deg. } 56 \text{ min.}$$

This angle is to 180 degrees as 2 is to the spiral lead *L* of the teeth. Hence:

$$\frac{16.93}{180} = \frac{2}{L}; \quad L = 21.26 \text{ inches.}$$

As the gear was of 12 diametral pitch, this lead gives an angle of spiral of about 38 degrees.

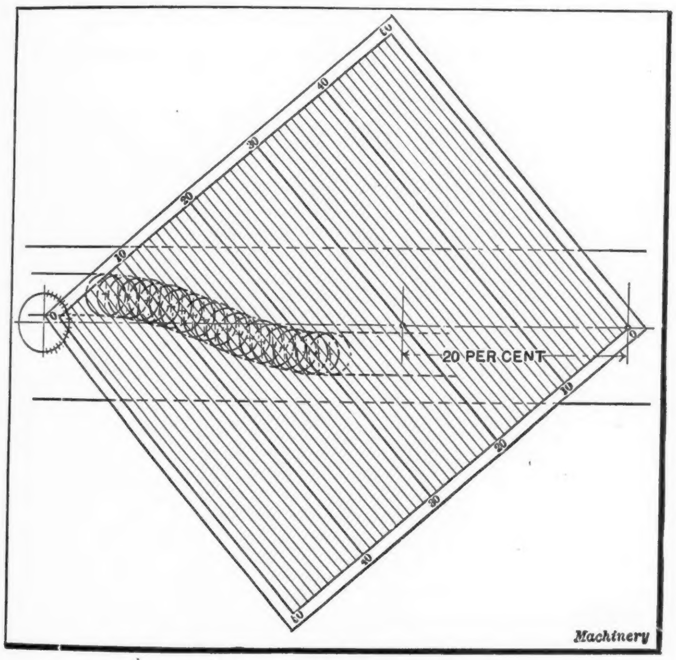
The accuracy of this method is limited only by the workman's ability to scribe and measure accurately, and with a sharp scriber in the height gage and painstaking care, very close results can be obtained. In this instance, the error was small, as subsequent correspondence with the maker of the gear showed that it had been designed for a lead of 21.262 inches, and very likely had been cut with a lead of 21¼ inches. The lead of spiral milling cutters often has to be determined in order that they may be recut. A similar method can be followed for these tools, the point *K* from which the measurement *KL* is taken being determined by the intersection of the circle drawn on the end of the cutter and the radial face of a tooth.

GUY H. GARDNER

Revere, Mass.

DEVICE FOR LAYING OUT DRUM CAMS

The accompanying illustration shows a simple device which is used in laying out drum cams. The writer has found this device to be a time-saver to draftsmen and believes it will prove of interest to some of the readers of MACHINERY. In laying out drum cams, it is necessary to lay out the percentages



Device for Laying out Drum Cams

of the cam movement on the center line of its lift. When doing this work in the ordinary way, the total length of the cam circumference is first laid out and then this length is divided up into percentages by some geometric method. This procedure, however simple, must be repeated for every section to be laid out.

The writer's method consists in having a piece of tracing cloth divided and ruled as indicated in the engraving, each tenth line being made slightly heavier than the others so as to make the counting of the divisions easier. This piece of tracing cloth is laid over the layout with the zero point at one of the ends of the line to be divided, and then the tracing cloth is swung around until the other end of the line to be divided coincides with the line on the tracing cloth numbered with the required number of divisions. The divisions to be laid out can then be pricked through onto the layout by the dividers. In the engraving is illustrated the method for laying out a 20 per cent cam movement. If two sheets are used, ruled with divisions 0.25 and 0.40 inch apart, respectively, these sheets will cover a large range of cam diameters.

ALFRED LAURENS

CURLING AND CLOSING DIE

The die shown in Fig. 1 is used for curling the hollow ring-shaped cup shown at *A* in Fig. 2 and locking the steel band shown at *B* within it. The punched cup shown at *A*, Fig. 2, is as it comes from the drawing die and trimming lathe, ready for curling and assembling with the band shown at *B*. The central portion of the cup *A* is left in place until

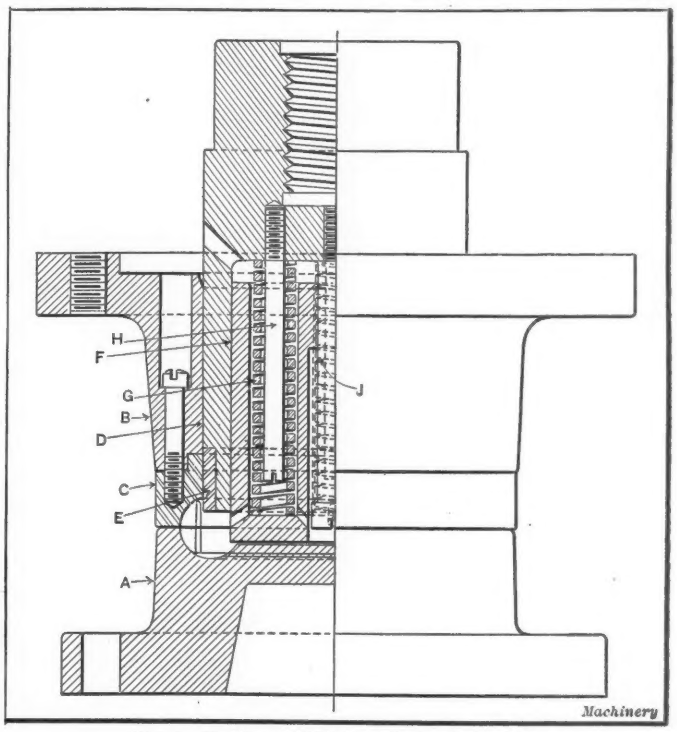


Fig. 1. Curling and Closing Die for Assembling

after the assembling operation is completed, as it serves to stiffen the work and enables it to be held more securely.

The base *A* of the die in Fig. 1 is an iron casting and is recessed in its upper surface to fit the cup, Fig. 2. As there is no rubbing or abrasive action in this die *A*, the cast-iron surface is of ample hardness, and saves the expense of inserting a steel ring. The upper portion of the tool consists of a cast-iron holder *B*, to the lower face of which is pivoted and screwed the curling die ring *C*, made from hardened tool steel. The closing punch-holder *D* is made of cast iron, bored out to receive the pressure pad *F*, which is acted upon by four stiff helical springs *G*, and is limited in its travel by the shoulder stud *J*.

The pilot studs *H* are of cold-rolled steel and are screwed

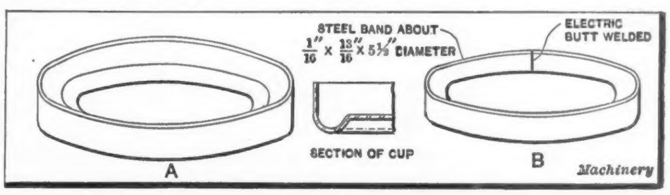


Fig. 2. (A) Cup before Curling and Closing. (B) Band to be assembled with Cup

into the punch-holder *D* for the purpose of guiding the helical springs into their pockets, and to prevent the pad *F* from rotating around the stud *J*. A steel band *E* is pressed onto the lower end of the punch-holder *D* to withstand the abrasive action to which it is subjected.

This die is held in a double-action press and is operated as follows: The cup *A*, Fig. 2, is placed in the groove in the base *A*, Fig. 1, and the band *B* is dropped into the cup. The punch descends, first holding the cup securely with the pressure pad *F*. Then the curling die descends, closing in the top of the cup, after which the closing plunger, which

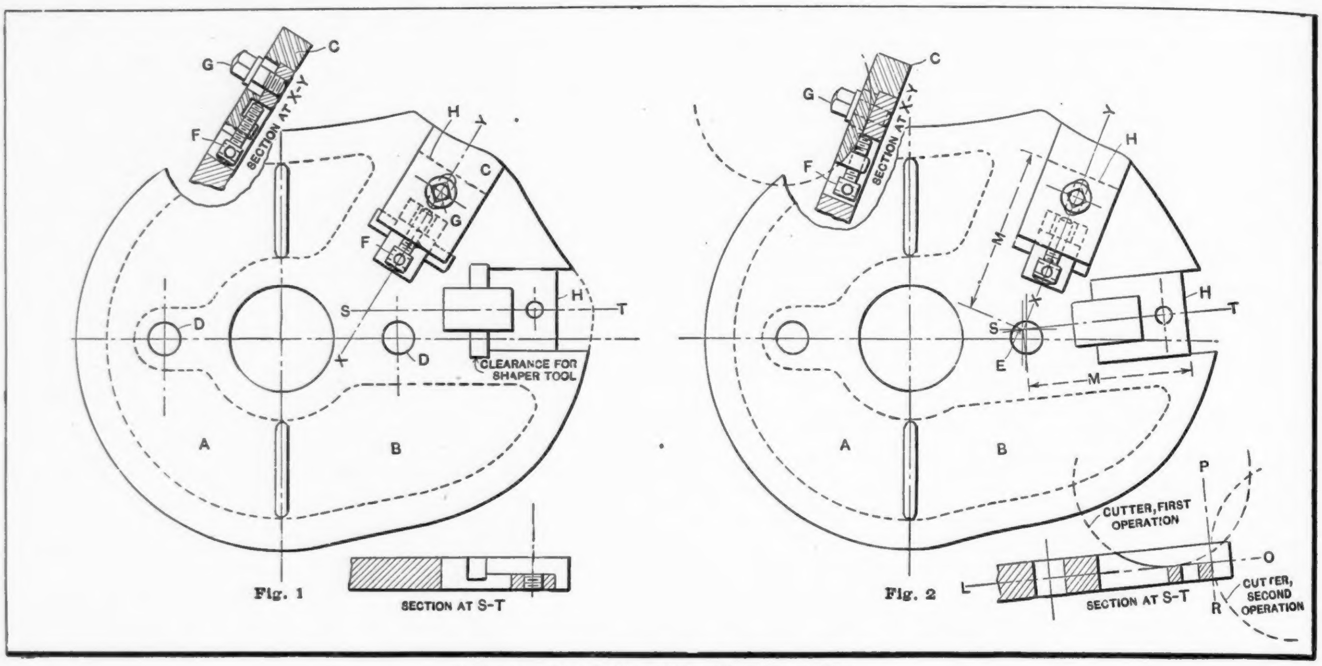
comes down slightly behind the curling die, operates and locks the band securely in place. The fact that the drawing punch of a double-action press descends after the blank-holder slide, combined with the necessity of holding the work when operating, in this case with the curling die first, makes it essential to use the long-stroke pressure pad and springs.

Detroit, Mich. ARON LAWRENCE

JIG FOR MILLING CAM SLOTS

In Fig. 1 is shown a cam used on a knitting machine. It consists of two halves, *A* and *B*, fastened to a flange, in the position shown, by the holes *D*. Part *B* is provided with two convenient manner The design of such a fixture, however, is not as easy as would be thought at first glance, since the center lines of the two slots in the cam intersect at a point which is not at the same distance from the edges *H* of the slots. In order to simplify the design of the fixture, the design of the cam was altered to that shown in Fig. 2. It will be seen that in the new cam the direction of the center lines of the slots is changed in such a way that the point of intersection *E* is at the same distance from the edge *H* of both slots. The parts *C*, however, remain at the same points on the outline of the cam.

Two operations are necessary for each slot. During the first operation the cutter finishes the top part of the slot, cutting



Figs. 1 and 2. Old and New Designs of Cam

slots which receive steel parts *C*. The latter fit exactly into the slots and may be adjusted by a hardened adjusting screw *F*. Another screw *G* is provided to hold parts *C* in their respective positions after being adjusted. These parts, however, are adjusted only at intervals, on account of the excessive wear at these points, although the adjustment also makes it possible to alter the shape of the cam to some extent when this is required.

along the line *LO*, while the second operation takes care of the front part and the correct length *M*, the cutter cutting along the line *PR*. The fixture used is shown in Figs. 3 to 6, inclusive, and is used for all the milling operations. It consists of a cast-iron base *A* (see Fig. 6) with two bearings *C*, each having a removable cap *D*. A cast-iron center piece *F* swings between these bearings by means of two journals *G* extending from *F*. These journals are cast hollow to reduce

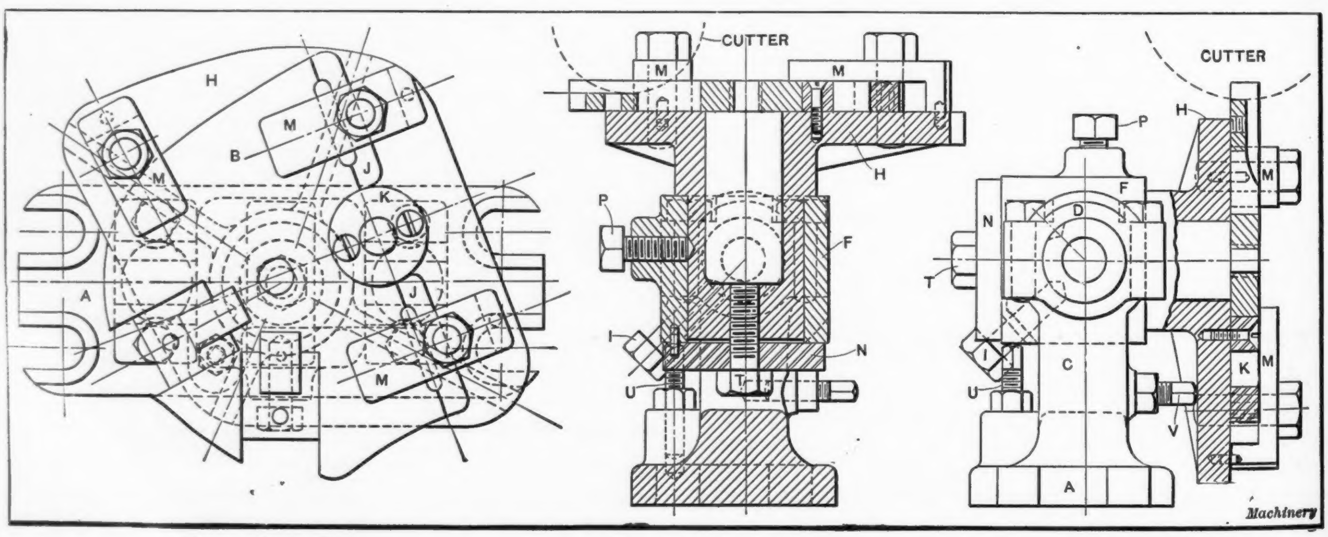


Fig. 3. Plan of Fixture Fig. 4. Section of Fixture Fig. 5. Side View of Fixture

Some years ago the slots for these adjustable parts *C* were shaped and the parts made to suit, but as the cams were later used in large quantities, this method proved unsatisfactory and it was decided to mill both slots by one cutter, so as to be sure that they would be of the same width. The parts *C* were to be finished by straddle milling cutters set the required distance apart. It was then required to construct a jig for performing the milling operation for both slots in an easy and the weight. In *F* a finished hole is provided at right angles to the axis of bearings *C*, to receive the cast-iron table *H*, which revolves in *F* and is provided with two projections *J* and a round steel disk *K*, the latter of which suits the bore of half-cam *B*. The cam is located by means of lugs *J* and disk *K* in such a way that the intersection point *E* (Fig. 2) of the two center lines of the slots coincides exactly with the axis *L* of the journal bearing about which it revolves.

Clamps *M* serve to hold the cam in position while it is milled. The clamps are provided with small steel pins which prevent it from turning around their bolts. The table *H* may be fixed in two positions so as to bring the center lines of the two slots into line with the cutter. The hardened center point of screw *P* fits into two corresponding holes drilled into the journal of table *H* at the proper places. The table is rigidly held to the center piece *F* by means of screw *T* and the bridge piece *N*. The latter is also provided with a small pin *S* and thus fixed in its position with relation to the center piece *F*. Fig. 6 shows the top view of the table set for the first slot, while Fig. 3 represents the same view with the table turned to cut the second slot.

After the top parts of the slots are finished, the latter must be cut to the correct length, finishing the front part at the

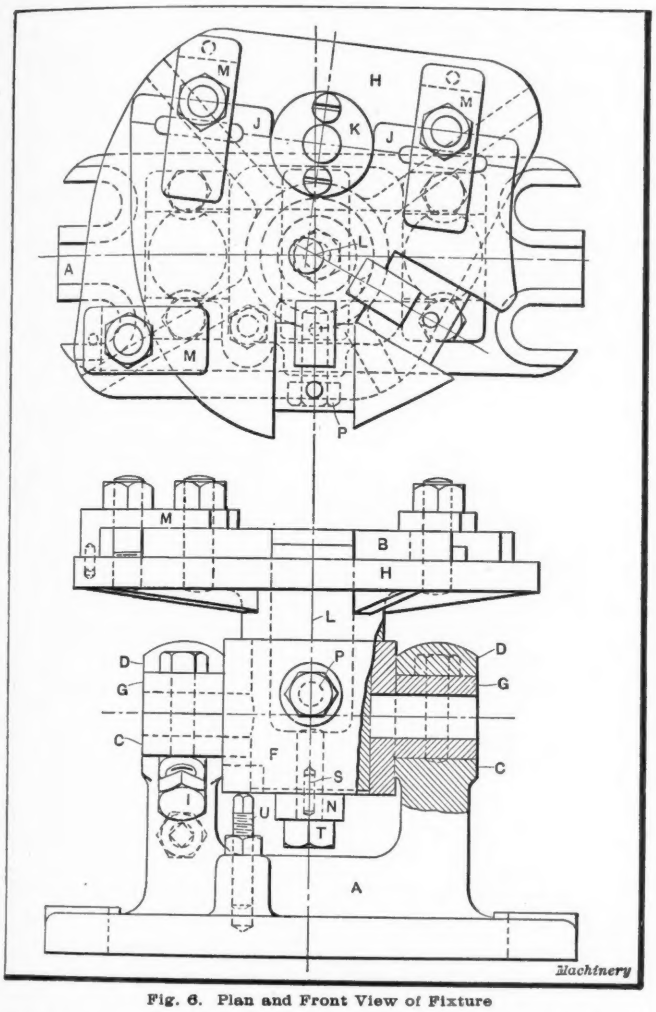


Fig. 6. Plan and Front View of Fixture

same time. To do this, the set-screw *I* is loosened and the center piece and table are swung around 90 degrees. In the first position, shown in the side-view section, Fig. 4, the center piece rests upon a screw *U*, while the top part of the slot is finished. When it is swung over, however, it rests against screw *V*, Fig. 5. Countersinks to suit screw *I* are drilled in the left side of the journal of the center piece *F* at the correct angles. The axis of *F* is arranged in such a way that the fixture is at once ready for the second operation, and no resetting of the cutter is necessary. To cut the front part of the second slot, table *H* is simply revolved as described before. It will be seen that in this way all the operations can be carried out rapidly and conveniently and without resetting the cutter or re-adjusting the milling machine table.

Wyomissing, Pa. CHRISTIAN F. MEYER

REPAIRING A CRACKED WATER JACKET

In the April, 1910, number of MACHINERY, a method of repairing a cracked water jacket of a gas engine cylinder was illustrated and described. In the following is given a different method for making repairs of a similar nature.

On the line of the fracture, drill and tap for a ⅜-inch threaded copper rod. This rod is screwed in firmly to a depth about equal to the thickness of the metal of the water jacket. Cut off the copper rod with a hacksaw, allowing it to project about 1/32 inch; then drill succeeding holes, each hole being drilled partly into the previously inserted copper plug, so that when all of the plugs are placed in the cylinder casting, they form a continuous band of copper along the line of the fracture. The copper plugs should now be peened down and trimmed off flush. The only possible chance for leakage, after having repaired the crack in this manner, is for the water to follow the joint between the metal of the jacket and the copper plugs, but, as the copper rods are threaded into the casting, it is not likely to occur. Should leakage take place, a little extra peening will suffice to prevent it.

Wilmerding, Pa. E. R. GROMAN

SEASONING CAST IRON

In response to the question in the "How and Why" section in the June number of MACHINERY, the writer would offer the suggestion that the best solution lies in so designing the parts that seasoning is either no longer necessary or so that the time required would be considerably reduced.

Every foundry-man knows that badly proportioned castings, that is, castings in which the metal cools at different rates, are subject to greater distortion than well proportioned ones. When cold, the stresses in the parts which cooled first are particularly severe, since added to their own stresses are the stresses due to contraction of the last cooled parts. Hence, if in any way an equal rate of cooling can be induced, castings less internally stressed will result. In the first instance, then, it is to the designer one must look for the cure, or rather the prevention. Let him see that the thick parts are reduced to the utmost possible extent, and then balanced by equally thick parts directly opposed. In certain cases the molder can influence the result by baring the thicker parts after solidification. He can also cast in proximity to the thin parts masses of metal to retard the cooling. The writer has often adopted this method. One case which migh be cited involved pulleys with a very thin rim, in which case a ring of metal was cast surrounding but not touching the rim. In another case of long angle bars, two bars of metal were cast along the two edges.

By any of these means the internal stresses are reduced; hence, their effect when metal is removed will be less also. But having attended to all these half remedies, there is another possibility. Take, for instance, a lathe bed, which by the best firms is always subjected to the ageing process. The top is planed and stresses are thereby released. It would, perhaps, be more correct to say that the metal under the severest stress is removed, and the planed surface is distorted by the pull from the metal at the opposite, that is, the bottom side. Why not remove an equal quantity of metal at the opposite side and so neutralize the effect? This is again a matter for the designer. As a rule, in a lathe bed, it is necessary to turn the bed over to plane the seatings for the legs. Why not extend the leg seatings the whole length of the bed? Then, before planing, lay out so as to insure an equal cut on both top and bottom. The writer has, in some instances, adopted this practice with the result that it was no longer necessary to season. FRANCIS W. SHAW

Manchester, England

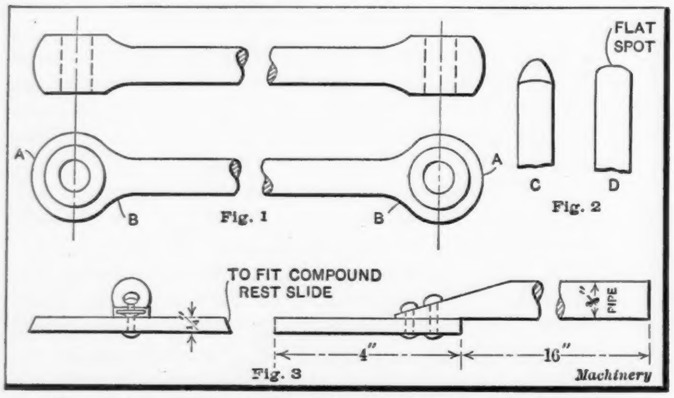
SPHERICAL TURNING

The spherical turning device described by Mr. C. Boella in the July number of MACHINERY, is probably good for the class of work for which it was designed, but the fixture is expensive and there are many classes of work that can be produced cheaper and simpler by the method described in the following.

In a large air-compressor plant where a great deal of spherical turning is done, various devices have been tried and discarded in favor of the simple method of using the compound rest as a spherical turning device. An example of the work done is shown in Fig. 1. This illustration shows a Corliss valve driving-rod having spherical surfaces turned at the ends *A* and fillets at *B*. When turning these, the compound rest on the

lathe is set so that the point about which it is swiveled is vertically beneath the center of the spherical section to be turned. The rest is then oscillated or swiveled so as to turn a spherical surface. The tool can be set at once to the desired radius when forgings are being turned having only a small allowance for finish. When, however, it is desired to take two cuts, the feed of the compound rest can be used for feeding in the tool for the second cut.

In order to be able to oscillate or swivel the compound rest, the binding screws are loosened enough so that an easy working fit is produced. The feed handle is removed and the operator uses the end of the compound-rest feed-screw as a means for swiveling the rest about its center, feeding the tool slowly around the work. Some operators reverse the compound rest so that the feed handle is at the back of the lathe, and then



Figs. 1 to 3. Work requiring Spherical Turning, and Tools used

use a handle as shown in Fig. 3. This consists merely of a piece of steel beveled to fit the slide in the rest and having a ¾-inch pipe about sixteen inches long riveted to it. This handle is inserted in the compound-rest slide and the pipe acts as a lever arm making it easier to swivel the slide about its center. In machining the fillet *B*, Fig. 1, the tool point, of course, must be moved past the swivel center of the compound rest.

The points of the cutting tools are shown in Fig. 2, where *C* shows an ordinary round-nosed tool which is used for roughing cuts, and *D*, a finishing tool. This is ground off to a comparatively large radius and is flattened off about 3/32 inch at the end. This tool, with soda solution as a cutting lubricant, finishes and polishes the work in one operation.

New Britain, Conn. J. M. Henry

CUTTING TWELVE TEETH IN A THIRTEEN-TOOTH BLANK

In the June number of Machinery, engineering edition, Mr. G. R. Hulsberg, in commenting upon Wuest herringbone gears, takes exception to some of the methods adopted in calculating and cutting these gears. He concludes as follows:

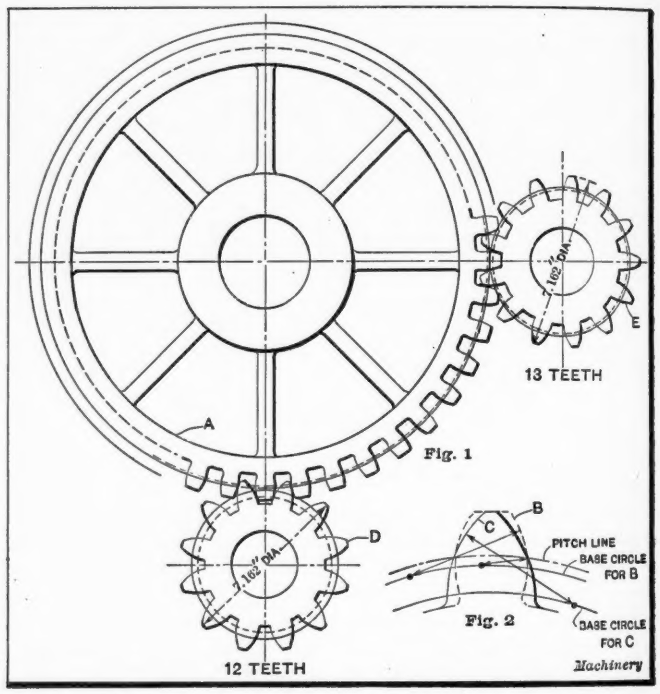
"Furthermore, in order to keep the center distance to some even dimension, the author simply reduces the pitch diameter of the gear to suit the center distance. By doing this, and keeping all the other quantities the same as before, the pitch of a gear is changed without changing the pitch of the pinion; hence, the gears will not mesh perfectly. The difference may be small, but interchangeability cannot be claimed on this basis."

The writer's experience with involute gearing indicates, however, that this supposition is not correct, and that, in fact, the diameter of the gears may be varied considerably from the calculated diameters without affecting the running qualities in the slightest degree, provided the proper method of forming the teeth is used. Some time ago a number of old planers were renovated, and, among other things, it was necessary to provide a complete set of new gearing and racks. The rack pinion was of mild steel, 13 teeth, 1½-inch pitch; the face width was 9 inches, the bore 3¼ inches, and the total length of bore 21 inches. It will be readily understood that the machining of the blank for this pinion from a solid 7¼-inch diameter steel bar involved considerable work, and that the finished gear was a fairly valuable piece. After the blank had been bored and turned the next operation was the cutting of the teeth. This was done in a gear-cutting machine, two cuts being taken.

Unfortunately, when gearing the indexing motion of the gear-cutting machine, the operator made one of those mistakes which seem almost inexplicable after they are discovered—he geared the machine for twelve teeth instead of for thirteen, and did not discover the error until one-half of the spaces had been roughed out. At first it seemed as if the only thing to do was to discard the blank and start on another. The writer remembered, however, that if a gear was cut in a generating machine (as distinct from a formed cutter machine) variations in the blank diameter were, within limits, unimportant. In fact, it is a recognized practice in some classes of work to increase the diameters in order to give the pinion teeth increased strength and durability. One firm in the town where this work was done had a generating machine large enough to cut pinions of the size mentioned. Arrangements were made with this firm, and in a few hours a finished gear was completed from the blank which had seemed to be only fit for the scrap heap. In fact, the pinion finished with twelve teeth was a better job than if it had had the full complement of thirteen teeth, as originally intended.

It may be suggested that the pinion could have been turned down to the correct diameter for twelve teeth and the teeth cut in the usual way. This, however, would have required another bull gear, and would also have left very little stock at the bottom of the teeth. Of course, the ratio of the gearing was affected by this alteration, but this was allowed for by a slight change in one of the other pairs of gears.

At *E* in Fig. 1, the pinion is shown as originally designed; *A* is the bull gear, and *D* is the pinion as actually made with



Figs. 1 and 2. Comparison of Tooth Forms in Pinions of Same Diameter with Twelve and Thirteen Teeth

twelve teeth. The dotted circles just inside of the pitch circles, in each case, represent the tooth curve base circles. It will be seen from Fig. 2 that the teeth of gear *D*, shown by full lines *C*, are stronger than the teeth of gear *E*, as shown by the dotted lines *B*. In this particular example we have the apparently paradoxical situation of a gear having 1½-inch pitch teeth accurately meshing with a pinion having 1⅝-inch pitch teeth, but there is no doubt whatever that if gears are cut by the generating process a slight variation in diameter makes no difference in their smooth working.

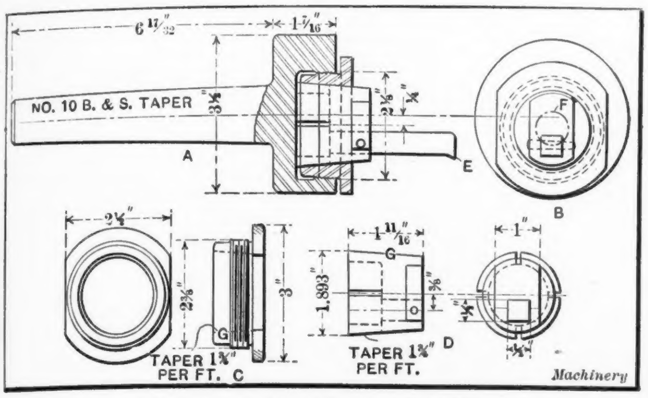
In conclusion the writer might mention that this twelve-tooth pinion has been in operation for about a year and the tool marks are still visible on the teeth. This is a good indication of the durability of the teeth when it is considered that the pressure on the teeth is about 9000 pounds during the cutting stroke and about 5000 pounds during the return stroke.

G. Ear

IMPROVED DESIGN OF BORING-TOOL HOLDER

The accompanying illustration shows a jig-boring tool that requires no set-screw to hold the tool. The use of set-screws, unless of the headless variety or those which do not project, is to be avoided in designing moving parts of machines or tools.

Referring to the illustration, *A* is the front elevation, shown partly in section; *B* is the end view of the assembled tool; *C* is a detail view of the locking nut; *D* shows the tool sleeve and *E* the tool, which can be made of any convenient dimension to suit the work. The shank of the tool-holder is tapered to fit the milling machine spindle. The head of the holder is



Improved Design of Boring-tool Holder

bored with an eccentricity of ¼ inch, and the square hole through the tool sleeve is also ⅜ inch off center. The circle *F* shows the amount of adjustment possible with the tool, which in this case is ¾ inch. The tool *E* is held in the tool sleeve by a taper pin.

In operation, this boring tool is similar to any other boring tool, except for the manner of varying the amount of eccentricity. This is accomplished by loosening the retaining nut, turning the tool sleeve and tool slightly, and tightening the sleeve again. The pressure of the retaining nut upon the tool sleeve holds the tool firmly, thus insuring an accurate cut.

Providence, R. I. ROBERT MAWSON

AN EFFICIENT ANGLE-PLATE FOR JIG WORK

When boring out jigs which require being clamped to the faceplate as well as to the angle-plate, strains are set up in the jig, so that when removed to drill a cross-hole, it will be found difficult to get the two holes in perfect alignment. An angle-plate which eliminates clamping strains, and does away with the necessity of clamping the work to the faceplate is

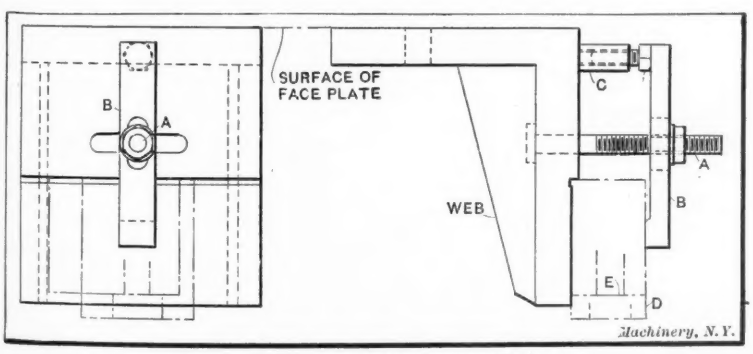


Fig. 1. Efficient Angle-plate for Jig Work

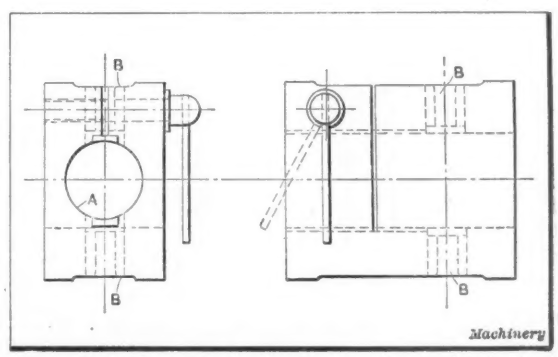


Fig. 2. Block Jig Illustrating Application of Angle-plate in Fig. 1

shown in Fig 1. This plate differs from the ordinary plate only in that it is provided with a clamping bolt *A*, strap *B*, and is planed out on the front end as shown, so that the jig will have a seat or shoulder to bear up against. A jack consisting of a stud and nut *C* is also provided to block up the strap.

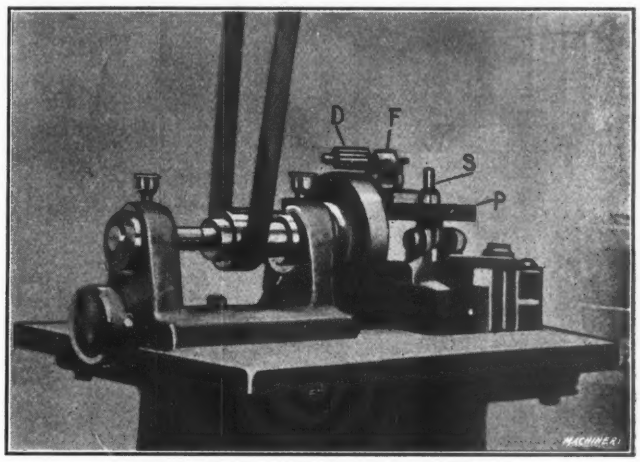
A jig which illustrates the application of this angle-plate is shown in Fig. 2, this being used for drilling and reaming a hole through a round bar. This is a simple jig, and is shown merely to illustrate one use of the angle-plate. In Fig. 1, the dot-and-dash lines *D* indicate the jig block in position for drilling, boring and reaming the large hole *A* in the jig, Fig. 2, while the dot-and-dash lines *E* show the jig block in position for drilling the small holes *B* in the jig Fig. 2. It is important when clamping the jig block to the angle-plate, that the block when changed from one position to the other should always have the same side in contact with the angle-plate, thus insuring that the holes will be in perfect alignment. JOHN R. JARVIS

New Haven, Conn.

EMERY-WHEEL TRUING DEVICE

The grinder shown in the accompanying illustration is used for grinding a special edge tool made in large quantities, the tools being gripped in a fixture reciprocated on the table *P*, the table being set at just the right height to clean up the face of the tools as they pass by the grooved surface of the wheel. These tools are ground with their faces straight and parallel within 0.001 inch, and hence the horizontal planes of the wheel, fixture, and table must be parallel. It was found that an adequate device must necessarily be provided for truing the wheel.

The table *P* swings about a horizontal axis through a short arc, and is held in position by lock-nuts on the stud *S*. The adjustment permits the wheel to be followed up at the pre-



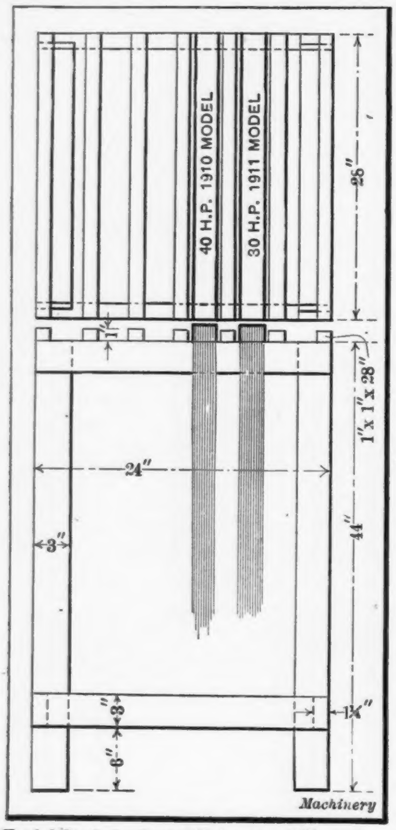
Device for Accurately Truing Emery Wheels

determined distance as its face wears off. No diamond was at hand for the truing of the wheel, and an ordinary emery-wheel dresser was out of the question for producing a straight parallel surface with sharp corners. The device shown in the illustration was, therefore, made, consisting of the cast-iron base *F* which is quickly attached to table *P* by thumb-screws, a half-inch shaft, and the dresser *D* which is made of a piece of carbon steel having a U. S. standard thread cut on its exterior, and then slotted longitudinally so that an end view has the appearance of a star wheel with sharp points. This tool is hardened but not drawn, and the hole in it is lapped to fit the shaft. When the base is attached to the table, the latter is lowered by the adjusting nuts until the wheel just touches the dresser, the machine being in motion. The dresser is then fed across the face of the emery wheel a couple of times. This device has proved very satisfactory, and produces a straight, sharp-cornered free-cutting face.

Middletown, N. Y. DONALD A. HAMPSON

DRAWING CABINET

The accompanying engraving shows a cabinet or rack for holding drawings or blueprints that have been bound together in volumes and are used regularly in the shop. It is simple in construction, but answers the purpose better than many more elaborate drawing cabinets and racks. It does not take a great deal of floor space, as the drawings are hung in a vertical position, while in most cabinets the drawings are laid flat, in a horizontal position. The title of each set of drawings is written on the back of the cover, so that it is always in plain sight and easily read. The top of the rack can be used as a reference table, it being level and of the proper height for that purpose. The construction of this rack is so simple that it can easily be made by any ordinary carpenter. The dimensions can be arranged to suit the conditions.

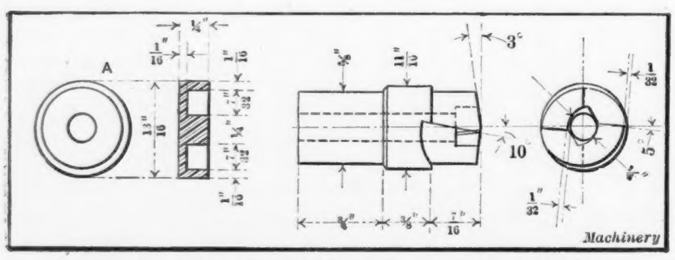


Useful Rack for Bound Volumes of Blueprints

Providence, R. I. ROBERT MAWSON

COMBINATION HOLLOW MILL AND COUNTERBORE

The accompanying illustration shows at *A* a section of a part made on the screw machine which, at first, appears to be a rather "mean" job. It will be seen that the recess is not very wide and the principal difficulty, obviously, is that when running at anything like an economical feed, a tool point small enough to do the work would spring slightly, cramp and break off. Having tried several forms of cutters, the



Combination Hollow Mill and Counterbore and Piece made by it

two-toothed mill shown was finally adopted and has given excellent results. It will be observed that one tooth cuts the outside of the recess, and the other finishes the cylindrical surface of the hub. Thus, with each tooth finishing a surface of its own, there is no cramping action. By having only two teeth, it is possible to make them strong enough to stand up and cut to size without springing. The large body of the tooth serves at the same time to rapidly dissipate the heat generated. The face angle is five degrees, the clearance three degrees, and the rake ten degrees. The work was done on a No. 2 Brown & Sharpe automatic screw machine.

P. A. FREDERICKS

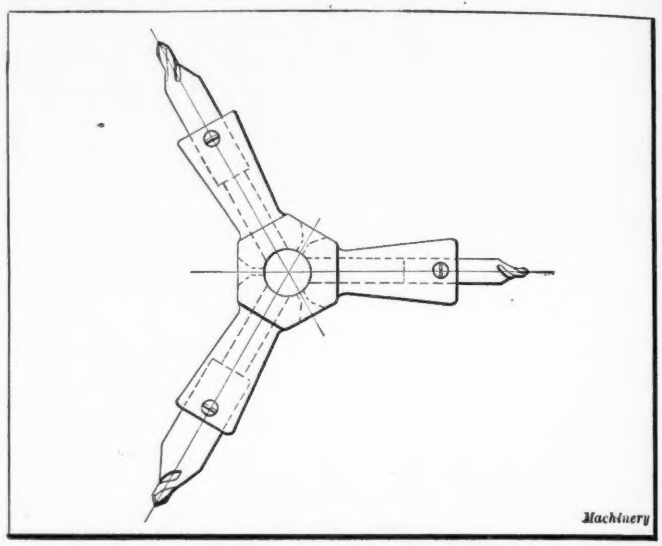
ERASING INK MARKS FROM TRACINGS

Inked-in tracings are easily discolored, marred and sometimes ruined through lack of proper treatment when making changes, but disfigurement of the tracing is not at all necessary if the alterations are made in a suitable manner. The above-mentioned faults can be avoided by observing the following rules. Always allow the ink to dry thoroughly, and do not use a blotter. In rubbing out, constantly turn the eraser so that different edges will be presented to the drawing. Using one portion of an eraser heats it up, and it will soon burn a hole in the tracing. After erasing a line or other inked-in part, rub the section slightly with soapstone. This will restore the finish to the cloth and prevent the ink from spreading. A small piece of soapstone will last an indefinite length of time and should be in every draftsman's kit. It is far superior to a knife handle and other similar contrivances which are sometimes used for this purpose. The above method of erasing will be found efficient if used with discretion.

Los Angeles, Cal. L. R. W. ALLISON

A CENTER REAMER HOLDER

A center reamer holder which will be found useful in connection with lathe work is shown in the accompanying illustration. It saves the trouble of chucking the center reamer every time it is necessary to drill a center in the end of a piece. The holder is held up against the tailstock center of the lathe and the reamer fed into the work. The three



Holder for Various Sizes of Center Reamers

holders make provision for accommodating center reamers of various diameters. The holder itself can be made from a 3½-inch round bar by cutting it off to the required thickness and then milling and turning it to form the three arms. Holes to suit the shanks of the center reamers can then be drilled, and 5-32-inch screws supplied for holding them.

C. E. D.

CUTTING WORMS OF STEEP PITCH IN THE LATHE

When cutting worms of steep pitch in the lathe, it is sometimes found impossible to drive the lead-screw through the usual train of gearing on account of the heavy stress that is placed on the first gear in the train, which frequently strips the teeth. The writer has overcome this difficulty by driving the lead-screw directly from the cone gear, using an attachment which would permit of this. The back-gears being in use, the cone on the lathe referred to had a velocity ten times that of the spindle; with the cone gear used as the driving gear in the train for the lead-screw, this had then ten times the velocity that the driving gear would have had if the drive were through the usual gearing. Hence, the stress on the teeth was proportionately reduced. Assume that a worm having 3½-inch lead is to be cut with a lead-screw having four threads per inch. The ratio of the spindle speed to that of the lead-screw is 14 to 1, but, by driving directly from the cone gear, the ratio will be 14 to 10, which makes it easy to obtain the gears; in fact, some leads could not be cut in any other way, as it would not be possible to obtain the required ratio by the gears available.

Brooklyn, N. Y. GEORGE E. OWEN

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

AMERICAN TOOL-ROOM LATHE

The American Tool Works Co., Cincinnati, Ohio, is manufacturing a new design of high-duty tool-room lathe, which is made in 14-, 16-, 18- and 20-inch sizes. These lathes have many features common to the standard design built by this company, including the drop-V bed, double-plate apron, quick-change mechanism giving 48 thread and feed changes, phosphor-bronze bearings, etc. In addition, the lathe is fully equipped with the various attachments required for tool-room work, such as taper, draw-in, and relieving attachments. It also has a pan for retaining the lubricant, as shown by the accompanying illustration Fig. 1. In case all of the attachments mentioned are not needed, any one of them can be furnished separately.

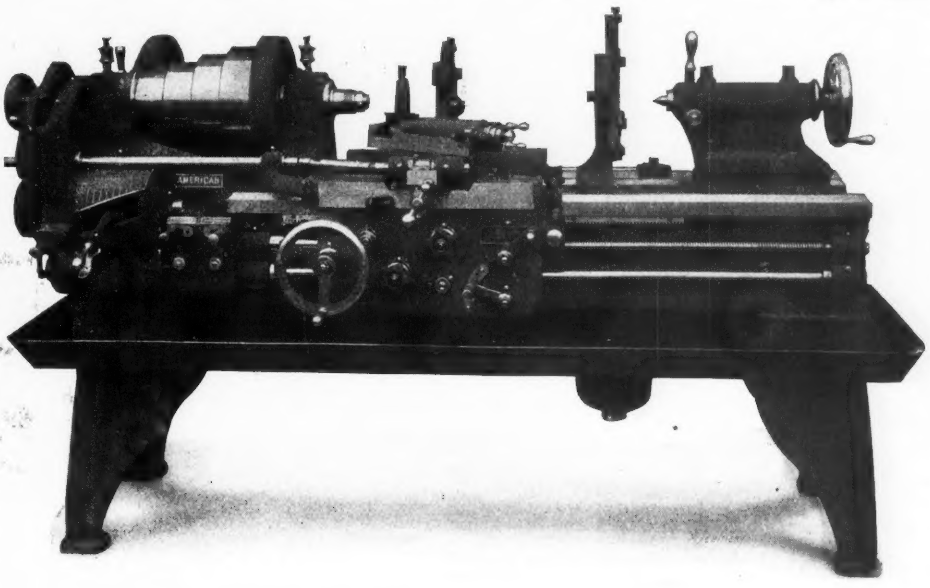


Fig. 1. American High-duty Tool-room Lathe

The taper attachment is simple, both in design and operation, and it is rigidly constructed, thus insuring accurate work. The attachment is bolted to and travels with the carriage, and can be engaged quickly at any point along the lathe bed, by simply tightening one binding nut on the clamping dog. When arranged for taper work, the sliding shoe is directly connected with the bottom slide of the tool-rest by a heavy cast-iron yoke which may be seen in Fig. 2. This construction eliminates lost motion and insures accuracy. The nut for engaging the sliding shoe is arranged to slide in a slot in the connecting yoke, and it is attached or released by tightening or loosening a single screw. Accurate graduations are provided and there is a hand-screw having a graduated collar for obtaining fine adjustments.

Fig. 2. Relieving Attachment of American Tool-room Lathe being used for Internal Work

The relieving attachment is applicable to relieving or backing off the flutes of cutters, taps, reamers, end mills, hollow mills, dies, etc. This attachment is universal in its operation, and end or internal relieving can be done just as easily as straight work. It has a direct drive and is of simple construction. The change-gear mechanism is supported by a bracket located on top of the quick-change gear-box, as shown in Fig. 1. The change gears are carried by a small quadrant which is used to disengage the drive when not required.

The power is derived from a spur gear located on the end of the main spindle, and motion is transmitted through the change-gear mechanism to the driving shaft which extends through the supporting bracket on the quick-change gear-box, and is journaled at the other end in a bracket fastened to the left side of the carriage as shown. Between the carriage bracket and tool-rest there is a universally jointed telescoping shaft which permits cross movement of the tool-slide.

The driving shaft revolves constantly in one direction until the rotation of the spindle is reversed, at which time the driving shaft ceases to reciprocate the tool-slide; consequently, the latter remains stationary when the direction of the carriage travel is reversed while the half-nuts are engaged. This feature is obtained by interposing a clutch connection between the cam and driver, which is operative in one direction only. Therefore, the reversal of the driving shaft causes the clutch, which is held into engagement by a spring, to be withdrawn from the cam with the result that the cam remains stationary. In order to cover the entire range shown by the relieving attachment index plate, three cams having one, two and four

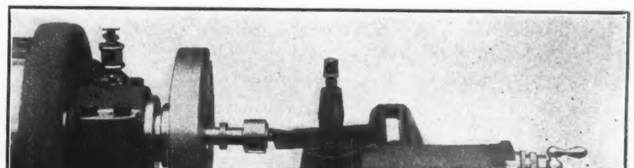


Fig. 3. An Example of End Relieving on American Lathe

rises, respectively, are provided in addition to the change gears. These cams can readily be interchanged, and they run in an oil bath.

This attachment permits the tool-slide to be operated at positions 30 degrees apart, thus providing twelve operating positions within a circle. This feature makes it possible to relieve side cutters, end mills, and various other tools. Fig. 2 shows the lathe being used for internal work and Fig. 3 its application to end relieving. Aside from adjusting the tool-slide to its proper position, no change or re-adjustment of the mechanism is required for internal or end relieving. Convenient means are provided for obtaining the various degrees of relief for either external or internal work. Adjustment is made at the front of the tool-slide by means of a thumb-screw, and the depth of relief is indicated by a graduated scale. This attachment can be applied and operated independently of the taper attachment.

A standard compound rest is furnished in addition to the special relieving rest, the former being recommended for general work. The compound rest can quickly be interchanged with the special tool-slide. The attachment can be arranged for relieving taps or hobs having spiral flutes by the addition of extra gears. In the construction of this attachment high-grade materials are used throughout. The cam yoke is forged and the cams, cam shoe and crank members are of tool steel, hardened and ground. The index bar in the top slide is of forged steel, and all shafts and gears are well proportioned. All gears are covered for the protection of the operator.

The draw-in attachment furnished with this lathe can be equipped with collets for holding stock up to 7/8 inch diameter on the 14- and 16-inch sizes, and up to 1 inch diameter on the 18- and 20-inch lathes.

COMBINED DOUBLE-HOUSING AND OPEN-SIDE PLANER

The planer illustrated in Figs. 1 and 2 was built for the Gas Traction Co. of Minneapolis, for planing the engine base castings used by that company in the manufacture of tractor engines. These bases require planing on the bottom, top and on both angular sides, as well as on the ends. As they are over six feet long, a standard planer, if used for planing the ends as well as the other surfaces, would, of course, have to be wide enough to permit the casting to pass between the housings, unless some form of extension tool were used, which would be undesirable. As the castings have a width of less than three feet at the top, the planing of the sides on such a wide planer would be objectionable, because of the distance to which the side-heads would have to be extended. Moreover a rigid support for the tools was desired to permit taking heavy cuts when planing the angular surfaces.

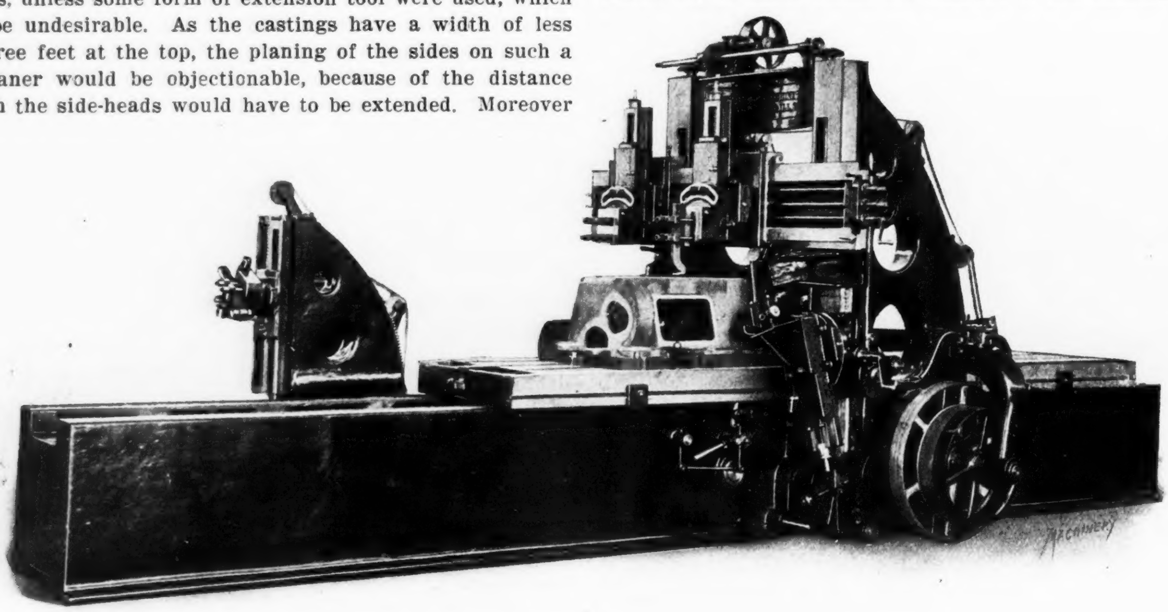


Fig. 1. Special Planer built by Rockford Machine Tool Co., Rockford, Ill.

The planer illustrated herewith was especially designed for this work by Mr. C. C. McConville (general superintendent of the Gas Traction Co.), assisted by the engineering departments of the Rockford Machine Tool Co. and Jos. T. Ryerson & Son. This machine has two heads on the cross-rail, two side-heads and, in addition, an auxiliary housing carrying a single head and located approximately four feet in front of the main housings. The engine bases are machined by first planing them on the bottom, two castings being finished at one setting. They are next mounted one at a time on a fixture which is pivoted in the center and can be accurately located in the different positions required by a heavy stop-pin. This fixture with an engine base mounted on it, is first placed parallel with the planer table and the top and two angular sides of the work are planed simultaneously. Fig. 2 shows the special tool bars or holders which are attached to the standard side-heads for this operation. This view also clearly shows the brackets which are clamped to the housings to provide a rigid support for the tool bars directly back of the cutting tools. After the sides are planed, the fixture carrying the castings is swiveled to a right-angle position and the end of the casting is finished by means of the head mounted on the auxiliary housing. This housing, which is shown in detail in Fig. 3, is located back far enough to permit the casting to clear it without changing the position of the work.

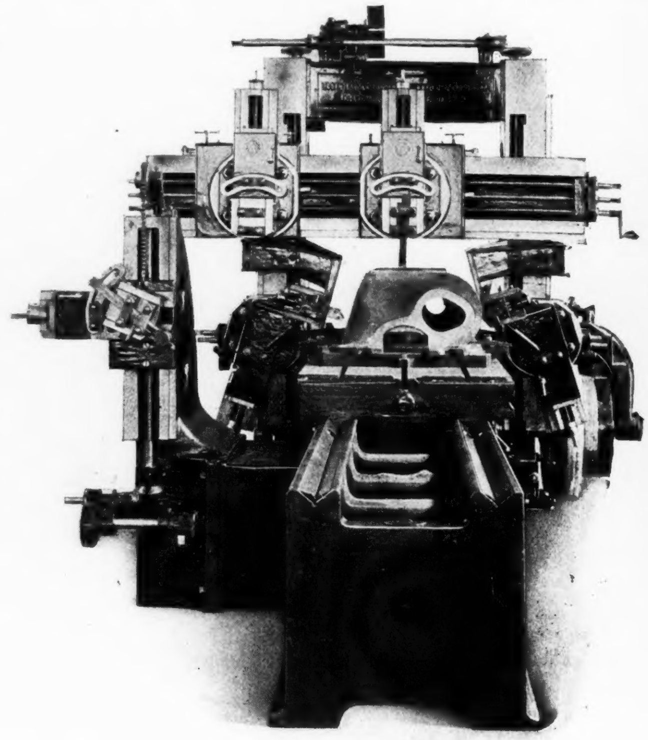


Fig. 2. End View of Combined Double-housing and Open-side Planer

The bed of this planer is a deep pattern, thoroughly braced by box form cross-girders, and it is further strengthened where the gearing and uprights are mounted. The length is such that there is very little overhang of the table when planing on full stroke. The table is of unusual thickness and the

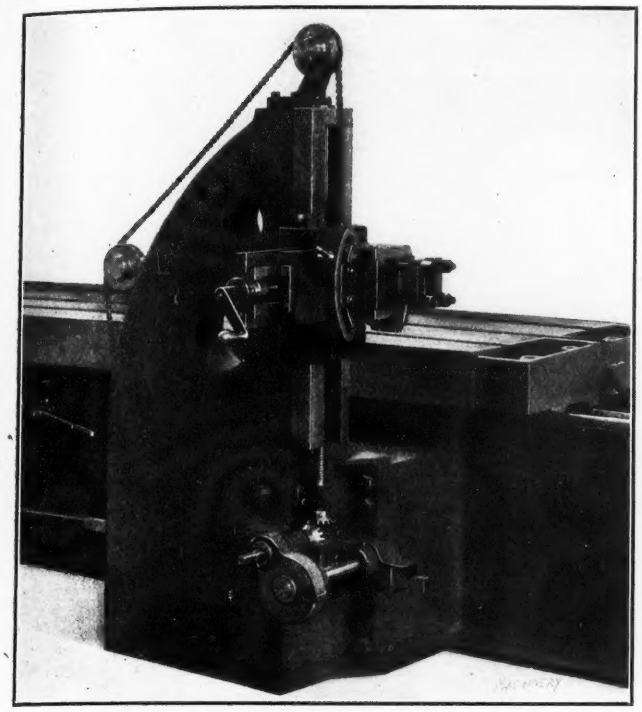


Fig. 3. Auxiliary Housing of Planer shown in Fig. 1

T-slots are exceptionally deep and planed from the solid. The cross-rail is of extra depth, and the down feed to the heads is unusually long. The saddle is graduated in degrees around the entire circle for angular adjustments. The side-heads are provided with vertical, horizonal and angular power feeds, and can be run below the top of the table when not in use. The down feed screws have micrometer dials, which are very convenient for making rapid and accurate adjustments for depth of cut. The shifting device is simple and is designed to transfer the belts quickly and noiselessly. There are shifter

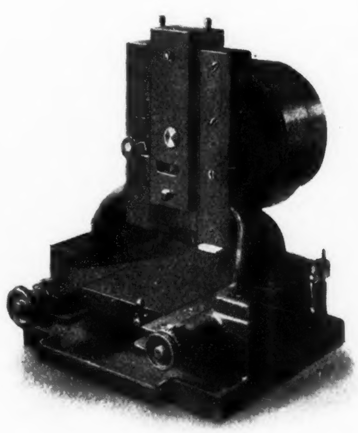


Fig. 1. Slotting Machine built by Swind Machinery Co.

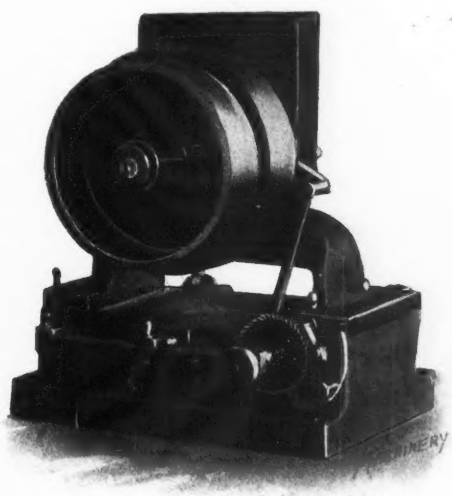
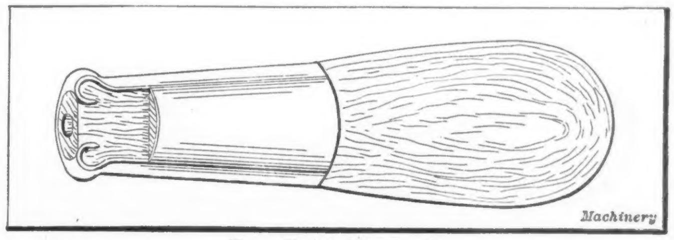


Fig. 2. Rear View of High-speed Slotting Machine

levers on both sides of the planer so that the operator can control the motion of the table without walking around the machine. Aluminum driving pulleys are used and all feed racks, pinions, and driving gears are of steel.

REINFORCED FILE HANDLE

The file handle illustrated herewith is a non-splitable type just placed on the market by the Doane Mfg. Co., Boston, Mass. This handle has a heavy pressed-steel ferrule which is enlarged at the end and curved inward as shown by the sectioned part of the illustration. When the ferrule is driven into place the end of the handle is locked within the enlarged or beaded end. These handles are made in five different sizes. The smallest



Non-splitable File Handle

size takes files from 4 to 6 inches, whereas the largest size takes 18- and 20-inch files.

HIGH-SPEED SLOTTING MACHINE

The slotting machine, front and rear views of which are shown in Figs. 1 and 2 respectively, was designed for slotting keyways in milling cutters and small parts such as are used in the manufacture of motorcycles, firearms, typewriters, sewing machines, etc. This machine has a vertical tool-slide and a horizontal work-slide which is gibbed in the body of the machine and serves as a fixture for holding the work. By turning a small handle in the front of the machine, this slide can be removed whenever it is desired to replace it with another slide or fixture especially designed for a given class of work.

The feeding movement, as well as the relieving of the tool, is accomplished automatically by the motion of the work-slide. This slide is advanced for feeding the work to the tool, in intermittent steps between which there is a short reverse motion for withdrawing the work from the tool during the upward stroke. This feeding movement and reverse motion is derived from the tool-slide, which has two lugs on the left side as shown in Fig. 1. These lugs alternately engage a short lever or finger attached to a rockshaft which, in turn, is connected with the feed mechanism by a vertical rod, as shown in the rear view.

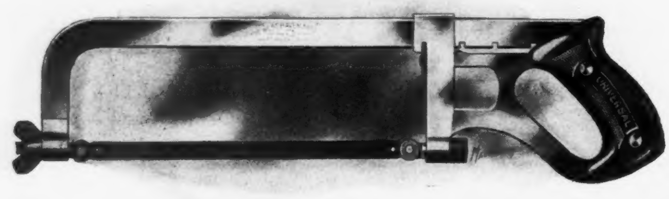
The action of the feed mechanism is as follows: When the tool-slide reaches the end of its downward stroke, the upper lug strikes the finger of the rock shaft, thus imparting a vertical reciprocating motion to the rod in the rear. This rod has a cam-shaped end which transmits the motion to a horizontal feed bar and the latter, in turn, gives a reverse movement to the tool-slide for relieving the tool on the upward stroke. When the top of the stroke is reached, the lower lug on the tool-slide engages the finger of the rock shaft and the resulting motion operates a ratchet and pawl mechanism, which, in connection with a screw on the feed bar, serves to advance the work-slide automatically a distance equal to the feed desired.

The feed mechanism has an automatic stop which can be set for any predetermined depth of cut and enables parts to be duplicated within close limits. The tool-head or slide is made of steel and is carefully scraped and gibbed. The vertical motion for the slide is obtained from a crank and connecting-rod driven by the two-step cone pulley in the rear. This machine has a capacity for cutting 3/8-inch keyways in cast iron and 5/16-inch keyways in steel. The maximum length of stroke is 2 inches, and a bench space of 16 by 16 inches is required. It is manufactured by the Swind Machinery Co., Bourse Bldg., Philadelphia, Pa.

EXTENSION HACKSAW FRAME

The hacksaw frame shown in the accompanying engraving is a style just placed on the market by the West Haven Mfg.

Co., New Haven, Conn. The back of this frame, instead of being collapsible, is made of a solid piece of 3/4 by 3/16-inch cold-rolled stock, thus eliminating any buckling action. The handle of this new frame is another noteworthy feature. It is molded from a special composition and is made to fit the hand so as to give an easy, natural grip. The frame is polished and nickel-plated and can be adjusted for blades varying from 8 to 12 inches in length.

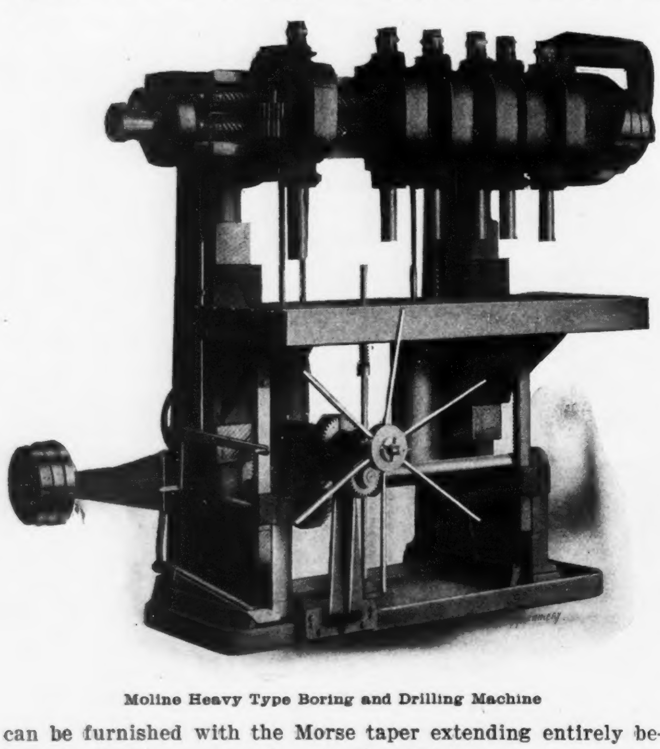


West Haven Mfg. Co.'s Hacksaw Frame

MOLINE BORING AND DRILLING MACHINE

The Moline Tool Co., Moline, Ill., has added to its line of drilling machinery a No. 12D heavy type boring and drilling machine adapted for rod boring and similar work. This machine has the double spiral drive which is regularly used by this company, but instead of having the lower spindle bearing vertically adjustable, the spindles run through the lower bearing full size. The lower bearing is bronze bushed and split so that the spindle wear can always be taken up, making in effect a lathe spindle construction. The spindles can be adjusted vertically by means of the upper bearings which are threaded, and they are equipped with ball-thrust bearings.

The heads are planed and scraped to an exact thickness and they can be equipped with tie-rods and spacer washers for setting them accurately to any distance along the rail. This is not necessary, however, for the general run of work, as the heads can be securely clamped in any position. The spindles can be furnished with the Morse taper extending entirely below the bearing and with a regular driving slot for moving the drills, or with short hollow spindles so that a knockout rod can be used. In the latter case, the Morse taper extends up into the bearing. The spindle shown at the left is back-geared for extra heavy boring.



Moline Heavy Type Boring and Drilling Machine

As the illustration shows, the cone pulley is provided with an outboard bearing. A plain table having five T-slots is recommended for cast iron work, but for steel a table that has three T-slots and is entirely surrounded by an oil groove, is furnished. In either case, the table is counterbalanced and it is fed by double, steel racks and pinions. The pinions are cut integral with the feed shaft and the latter is driven by steel and phosphor-bronze 4-pitch spiral gears. The table is provided with an automatic trip, a spring down stop and a positive depth gage. The hand feed is back-geared, and for facing operations the automatic trip can be set to disengage slightly ahead of the depth gage, for feeding the table up to the positive depth gage stop by hand. By pulling the pilot wheel out, a quick return is secured for the table.

BARNES NO. 5 GAP LATHE

The W. F. & John Barnes Co., 231 Ruby St., Rockford, Ill., is now manufacturing a No. 5 gap lathe of 11–15-inch swing. The particular lathe shown in the accompanying illustration is equipped with a foot-power drive, but a friction-clutch countershaft can also be furnished for power driving. This lathe is a screw-cutting type and the change-gears provided can be combined for cutting threads ranging from 4 to 40 per inch. In addition, other pitches not given on the index-plate can be cut.

The carriage has a compound rest, and the tailstock is the offset type which permits the compound rest to be set parallel with the bed. The compound table has transverse T-slots for clamping parts that require boring or milling operations. This is a very convenient and valuable feature, especially when the lathe is to be used for a wide range of work. The headstock boxes are accurately fitted to the spindle and provision is made for taking up wear. The spindles of both head- and tail-stocks are of steel and have accurate taper holes for the reception of the centers. The gearing is accurately cut from the solid, and the works are carefully protected from chips and dirt.

Barnes No. 5 Gap Lathe

The No. 5 gap lathe is made in one style only and with one length of bed. The swing over the bed is 11 inches; over the tool carriage, $6\frac{5}{8}$ inches, and in the gap, 15 inches. The width of the gap from the faceplate is 5 inches, and the maximum distance between the centers, 29 inches. The net weight of the lathe is 500 pounds.

LEBLOND HEAVY-DUTY CONE-TYPE MILLING MACHINE

The R. K. LeBlond Machine Tool Co., Cincinnati, Ohio, has brought out a new line of cone-type milling machines. Figs. 1 and 2 show the side and front views, respectively, of a No. 4 size of the plain type. The distinctive feature of this design is that the machine is essentially right-handed. A study of productive and non-productive movements resulted in placing all the controlling levers on the right-hand side and grouping them for right-hand manipulation. The operator can control

every function of the machine without changing his position, unless the range of a machine is so large as to make this impossible.

The column is a one-piece heavy-ribbed box casting and it is cast integral with the base in order to transmit the strains due to heavy milling through the vertical walls to the base.

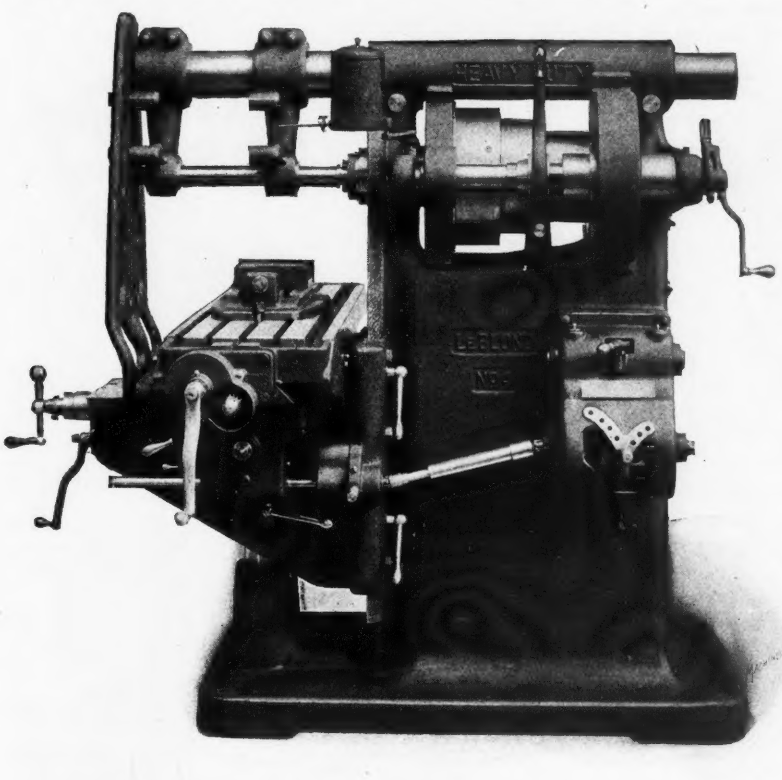


Fig. 1. The Le Blond No. 4 Cone-type Milling Machine

The back-gears are of the double-friction type. They are thrown in and out of mesh by a conventional eccentric shaft arrangement, and are clutched to the back-gear shaft by a powerful friction in the hub of each gear. This friction consists of three parts, *viz.*, a hardened steel double-taper key, a hardened steel plug with an acute taper, and a cast-iron friction ring. When the key is drawn against the plug, the friction ring is expanded in the gear hub. This ring is snapped over the hub to prevent any drag when the clutch is released, so that the lever may be used for starting and stopping. The change from a high to a low ratio can be made while a cut is being taken, and the driving tension can be varied by regulating the pressure on the lever.

The feeding movements are all derived from a single self-contained unit attached to the side of the column. Front and rear views of this feed-box are shown in Fig. 3. The initial drive is from a gear, mounted on the cone so that any change in the driving speed also effects a change in the feeds. The initial shaft is given three speeds; first, with the open belt drive, second, with the low ratio back-gear, and third, with the high ratio back-gear engaged. The feed-box is controlled by the two levers shown. The changes are advanced in small steps by the lower lever, whereas the upper one is used for compounding. Sixteen changes are obtained in the feed-box, and as there are three speeds for the initial driving shaft, a total of forty-eight changes, advancing by small increments, is available. The feeds are inversely proportioned to the speeds, thus obviating speeds that are detrimental to the gear-box. When high spindle speeds are used, the box is driven by a pinion, and when heavy cuts are being taken, thus necessitating large cutters and coarse feeds, the box is driven by a large gear, which increases the speeds about eight times. The gears are all made of crucible steel and they are brought into mesh by peripheral and sliding engagement. The sliding gears have rounded teeth to facilitate meshing, and the tumbler gears have pointed teeth and a heavy root section.

A universal shaft transmits power to the feed trip and reverse box. From this point, motion is imparted to the table through accurately cut spiral gears and spur gears. The feeds are tripped by a single plunger having a direct lever arm action. The trip acts directly on the releasing lever which drops into a neutral position after being tripped. Depressing this lever, feeds the table to the right, and elevating it feeds the table to the left.

The spindle is made of 60-point carbon, crucible steel. For the front bearing, a hardened steel taper bushing is pressed over the spindle and runs in a special close-grained cast-iron box that is drawn into the column by a nut on its rear end. The journals soon become highly polished as the result of contact with the hardened steel spindle, which, in conjunction with the thorough lubrication, reduces the bearing friction to a minimum. The rear bearing is a bronze mixture and has a straight fit in the journal, but is tapered on the outside so that it can be drawn into the column to adjust for wear. There are large cored pockets under each bearing from which the oil is drawn through a piece of felt by capillary attraction. In this way, the bearing is supplied with a flow of filtered lubricant and the flow increases as the speed increases.

The steps of the cone pulley are unusually large in order to use a wide belt operating at rational speeds. The countershaft is so speeded that a shift from high to low is always intermediate to a change on the cone pulley. This enables the countershaft speeds to be kept close together so that on the slow speeds, when the most power is required, the countershaft is operating at a high speed, and maintaining a high belt velocity and high initial torque. This also permits the eighteen spindle speeds to be obtained successively, with but eight belt shifts.

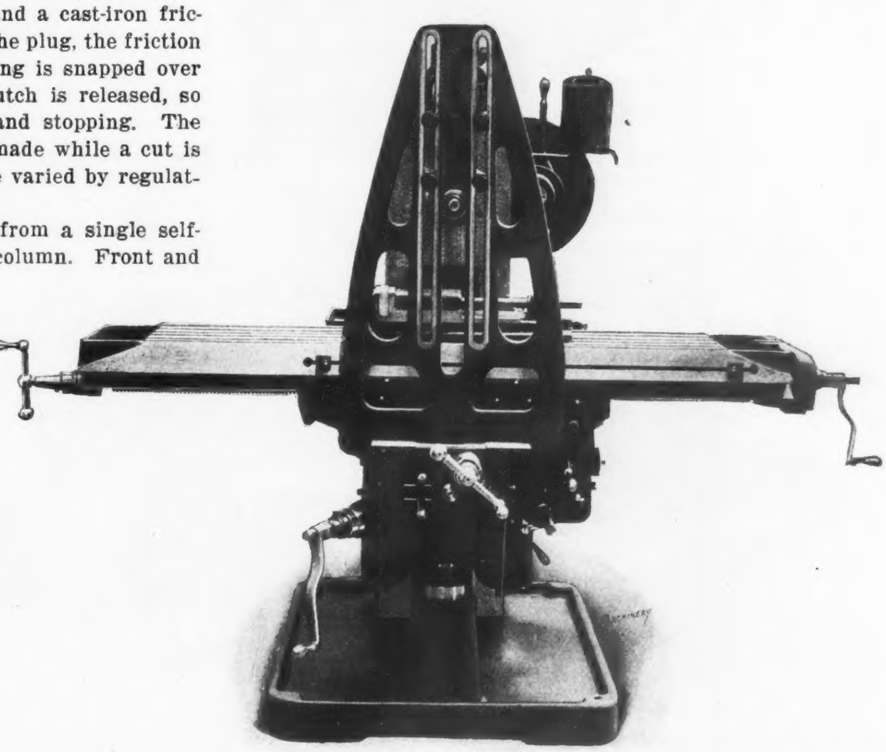


Fig. 2. Front View of Le Blond Milling Machine

The knee is a full box section, ribbed laterally and transversely to resist torsional and collapsing strains. All the openings have been reduced to a minimum and are located so

as not to impair the strength. The ribbing divides the casting into a series of box-section compartments. The cross-feed screw is in the center of the knee so that there are no unbalanced strains. The saddle is a heavy well-ribbed casting that occupies as little vertical space as is consistent with the required rigidity. The design of the saddle is shown in Fig. 4, which is a detailed view with the table removed. The knee and saddle are bound in their respective positions by heavy

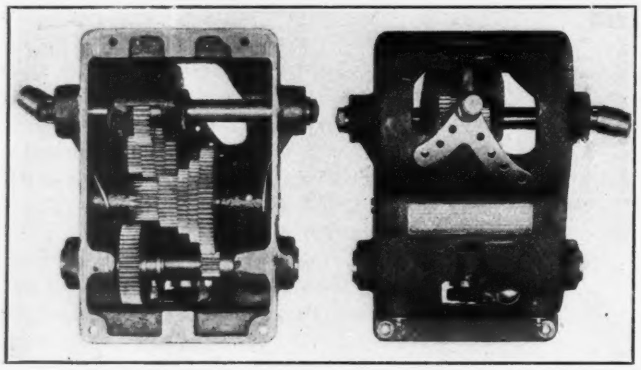


Fig. 3. Feed Mechanism of LeBlond Milling Machine

binder handles. By means of these handles a double-angle gib is operated which draws the parts together against the solid angles and at the same time maintains a continuous metal-to-metal contact.

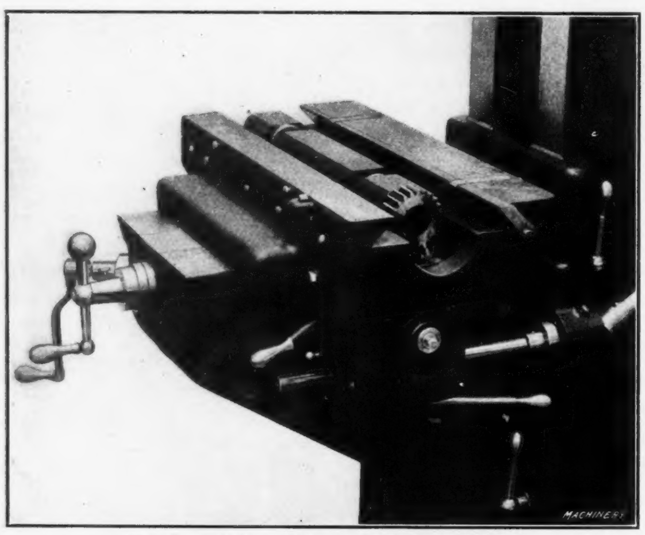


Fig. 4. Saddle and Knee of LeBlond Machine

The table is a semi-steel casting, having considerable vertical depth to resist buckling when the work is clamped to it. An oil channel is cast completely around the table and there is a pad at the extreme end for mounting the dividing head. In this way the capacity between centers is increased about eight inches. The feed-screw is cut from a 50-point carbon, crucible steel bar and has a lead of 2/5 inch. The brace, which is clearly shown in Fig. 2, is a solid casting designed to resist the strains to which it is subjected. The overarm is a solid steel bar which is accurately ground to size. This new line of milling machines includes sizes from No. 0 to No. 4, in both plain and universal designs.

ROCKFORD 14-INCH MOTOR-DRIVEN DRILL

The motor-driven drilling machine shown herewith is an improved design brought out by the Rockford Lathe & Drill Co., Rockford, Ill. This machine is driven by a $\frac{1}{2}$-horsepower motor which can be furnished to run on either a direct or alternating current of any required voltage. The power is transmitted to the lower cone pulley through a train of gears containing a rawhide idler which gives a silent drive. There is a tilting table which can be securely clamped at any angle. This feature, in conjunction with an angular bracket on the table, makes it comparatively easy to do many difficult drilling jobs.

Rockford 14-inch Motor-driven Drilling Machine

The spindle is of high-carbon steel, forged and ground. It is fitted with a ball thrust bearing and is counterbalanced either by a weight and chain or a quick-return spring. The distance from the column to the center of the spindle is $7\frac{1}{4}$ inches; the diameter is $\frac{7}{8}$ inch; and the diameter of the sleeve $1\frac{5}{8}$ inch. The spindle has a vertical travel of $5\frac{1}{2}$ inches, and the maximum distance from the end of the spindle to the table is 35 inches. The head has a vertical adjustment of 9 inches. The table is 11 inches square. The largest and smallest steps on the cone pulleys have a diameter of $7\frac{3}{4}$ inches and $3\frac{5}{8}$ inches, respectively, and the steps have a face width of $1\frac{5}{8}$ inch. The machine has a $\frac{3}{4}$-inch capacity, and its net weight is 355 pounds.

CLEVELAND FRICTION CLUTCH

The friction clutch shown in the accompanying illustrations is made by the Cleveland Clutch Co., 224 High Ave., Cleveland, Ohio. This clutch is an expanded-ring self-oiling type. The principal advantages claimed for the design are, durability, simple construction, smooth positive action, ease of adjustment, adaptability and high efficiency. In addition, it is dust-proof and oil-tight and is well balanced.

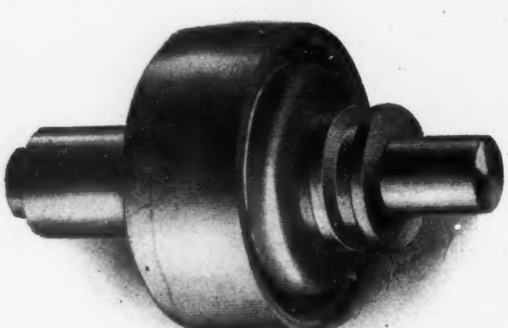


Fig. 1. Cleveland Friction Clutch

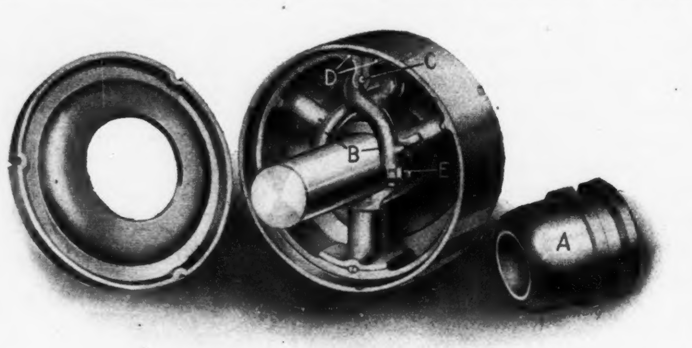


Fig. 2. Interior View of Cleveland Clutch

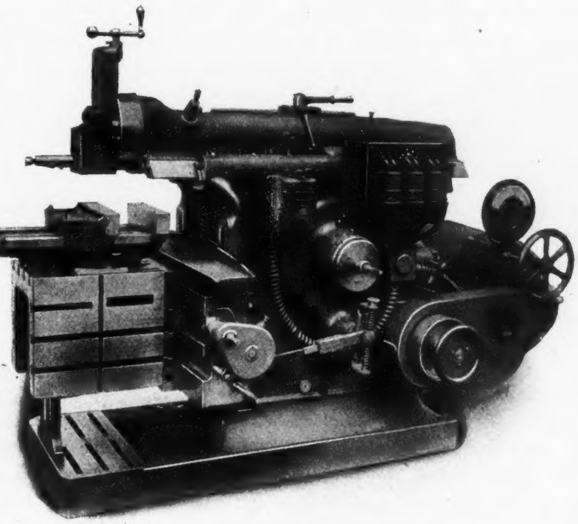
Fig. 2 shows clearly the construction. The spider is keyed to the shaft and the clutch is operated by shifting cone *A*, which engages fingers *B*. The latter are held by a floating center *C*, which causes points *D* to move along the same arc as the friction band. Both casing and spider are made of cast iron. The expansion band is of semi-steel and the fingers are

drop-forgings. The cone is of Bessemer steel and the pins are of casehardened steel.

Provision for easily adjusting the clutches for a given load is made by set-screw and lock-nut *E*. The friction surfaces have metal-to-metal contact and no wood or fiber is used in the construction. A film of oil has to be displaced before the clutch is fully engaged, so that it takes hold gradually but releases instantly. After the clutch is once oiled, it can be operated for months without further attention. It is not affected by centrifugal force and is adapted to either high or low speeds.

GOULD & EBERHARDT 24-INCH SHAPER

Gould & Eberhardt of Newark, N. J., has recently designed a new line of shapers adapted to the heavy work required in steel mills, railroad shops, drop-forging shops, etc. The bull gear of this new design has been raised considerably and it is a new patented construction. This improved feature is said to greatly increase the mechanical efficiency of the shaper. In addition to this change in the design, there are the following improvements: The outside diameter of the bull gear hub has been increased from 3¾ to 6 inches; there are larger V-bearings, and the gib is so arranged that there is a solid metal-to-metal construction on each side of the ram bearing; the main lever has a solid top; the overhang of the crankpin has been reduced to a minimum; the crankpin thrust is taken by solid walls in the bull gear similar to the ways of the ram; the ratio of the "double-train gear drive" has been increased; the front table support is of heavier design; and the head, ram and frame are of more massive construction.



Gould & Eberhardt Shaper with Variable-speed Motor Drive, Automatic Starter, and Dynamic Brake Control

In the design of the V-gib bearing, which gives a solid metal construction on both sides of the ram, a taper gib is provided having two parts. These can be adjusted independently of each other from the side, near either the front or the back end. This adjustment is in an upward direction between the ram bearing and the solid bearing in the frame, and it is effected by means of set-screws. The arrangement is such that the ram has a solid metal-to-metal bearing for all positions of the adjustable gibs.

In order to determine the relative merits of the V-form of ram, as compared with the square-gib type, a test was made at the University of Michigan with two Gould & Eberhardt shapers, one having the V-ram and the other the square-gib construction. A partial report of this test is as follows:

"The results show the V-form of ram to be superior in all but one of the points investigated. In the horizontal deflections, the square machine has a uniform advantage. In vertical deflections, wear, efficiency and convenience, the V-shaper shows a marked superiority, and it is the author's opinion that a more thorough and exhaustive test would place the V-slide even further in the lead as an accurate, efficient and economical means of transmitting linear motion."

The V-gib of this new shaper has an angle of 55 degrees instead of 45 degrees. This angle was adopted as being better able to withstand the horizontal strains of the ram, without sacrificing the advantages of the V-type bearing for taking the vertical strains. The amount of bearing surface has also been increased in order to further preserve the alignment and accuracy of the ram.

The main lever, instead of having a hole at the top for use when keyseating long shafts, has been made solid to increase the strength, and means are provided for keyseating by placing a hole in one side of the frame, through which shafts up to 3 inches in diameter can be passed. This arrangement is patented. By reconstructing the main bull gear, the overhang of the crankpin, with relation to its distance from the large gear hub bearing in the frame, has been reduced to a minimum. Straps and bolts for holding the crankpin to the large bull gear have been done away with, and solid V-ways similar to the ways of the ram are provided. This forms a solid dovetail bearing for the crankpin, which is superior for taking the strains and thrusts.

The ratio of the double-train gear drive has been increased by giving the shaper a greater initial speed and increasing the ratio of the gearing. This gives more power to the machine when running in single gear or with the back-gear engaged. The ratio of the single gearing is 6.64 to 1; the ratio of the back-gearing, 32.06 to 1.

This shaper weighs 4800 pounds, and is shown in the illustration with a direct-connected, Reliance, variable-speed motor, an automatic starter and dynamic brake control. The horizontal travel of the table is 28¼ inches and the vertical travel, 14 inches. The maximum distance from the ram to the table is 17½ inches and the tool-head has a vertical movement of 8 inches. The vise jaws measure 14½ by 3 inches and the vise has a maximum opening of 16 inches.

NEW BRITAIN AUTOMATIC MULTIPLE SPINDLE CHUCKING MACHINE

The "size 33" automatic multiple spindle chucking machine shown herewith (which is built by the New Britain Machine Co., 64 Bigelow St., New Britain, Conn.) embraces several improvements, and also permits the machining of pieces which heretofore could not be done on this machine. It will be noticed by referring to Fig. 1 that this machine is of the single-head type.

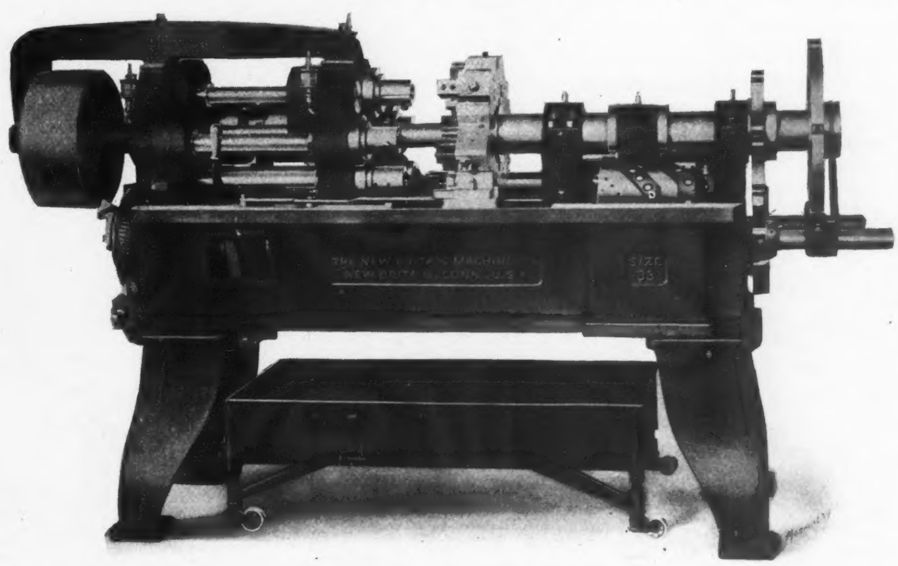


Fig. 1. New Britain Multiple Spindle Chucking Machine

The most important improvement is that the machine has five working spindles, the chuck turret being equipped with six openings, all but one of which are in line with the spindles. Thus work can be performed on five pieces simultane-

ously. If desired, either of the last two spindles can be used plain for reaming, or if fitted with frictions, either or both may be used for threading. As on other machines of this type, the time for completing a piece equals the time required for the longest single operation; and as it is possible to distribute long operations over the different spindles, it will be seen that such operations can be performed in the time required for a comparatively short operation.

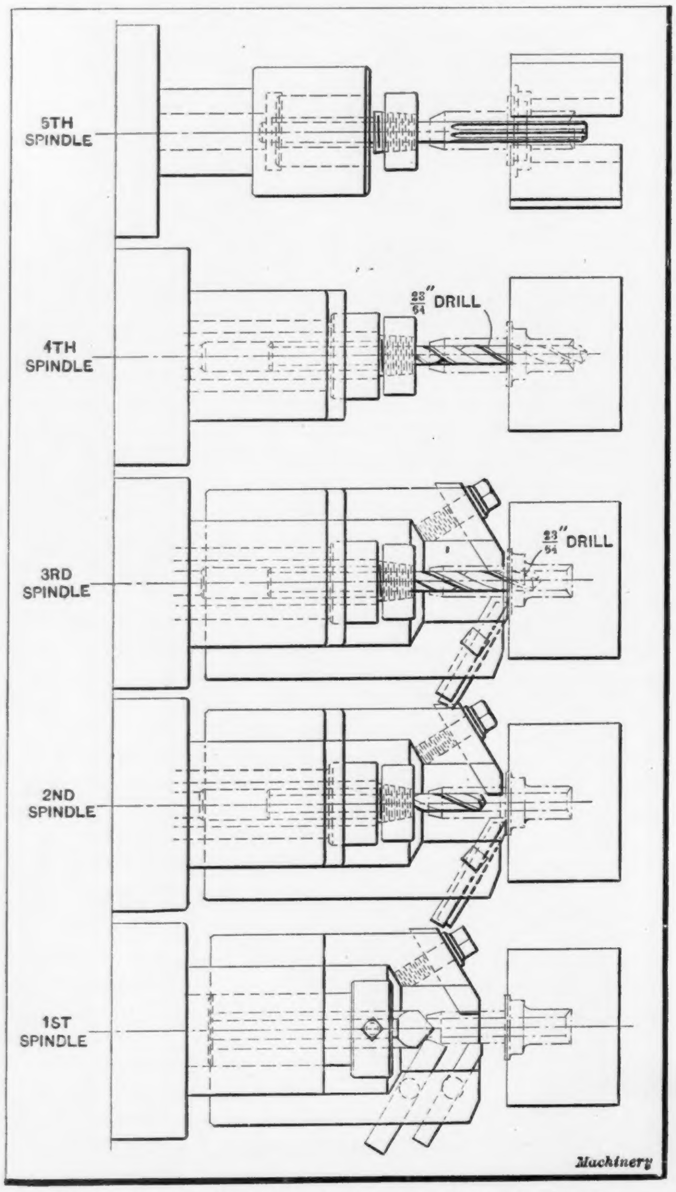


Fig. 2. Example of Work done on New Britain Chucking Machine

On the size 33 machine, an overhead arm has been added which securely ties the two heads together, and, moreover, extends so as to form an outboard bearing for the driving pulley, thus equalizing the belt pull upon both ends of this bearing. It is interesting to note the method used in tying this overhead arm to the two heads, the construction being such that the heads are held rigidly but without subjecting the attaching bolts to a shearing strain. This is done by providing the two bearings of the overhead arm with longitudinal tongues which fit into corresponding slots which have been milled in the two head bearings. In addition, the bolt holes are fitted with hardened steel bushings which extend into the heads and thus protect the attaching bolts from shearing action.

The cam roll yoke which was formerly held in a fixed position on the turret barrel, is now adjustable lengthwise. The yoke runs on a split sleeve which is clamped to the turret barrel by two tangent screws. The advantage of this feature lies in the fact that if it is desired to advance the action of all tools a short distance, it can be done by simply moving the position of the yoke upon the barrel. Formerly it was necessary to move each tool or to change the cam position to secure this result. The size of the turret barrel has been materially increased, thus providing for handling heavier turrets or faceplates with fixtures. The turret bar, or shaft upon which the turret slides as it moves forward, is supported at one end in the head of the machine and at the other in a ground hole in the turret barrel.

A steadyrest of the sliding-key design automatically locks the chuck turret in both directions while the tools are in operation. This steadyrest, which can plainly be seen in Fig. 1, is actuated during indexing by a cam and roll action which is entirely automatic. The faces of the steadyrest are adjustable to compensate for wear, and maintain the accuracy of the machine by supporting the turret chuck near the working position. By supporting the turret at that point, the turret barrel is relieved of all torsional strain and the indexing mechanism from pressure.

The working range of the machine covers pieces requiring a cam stroke of 3¾ inches, and diameters up to 1½ inch can be turned or bored. Larger diameters may be finished when the length of cut is less than the full stroke of the cam.

As an illustration of a typical job which may be handled on the size 33 machine when equipped with high-speed drilling spindles in the No. 2-3-4 spindles, the tool lay-out for a valve stem guide is shown in Fig. 2. These valve stem guides are 3 inches long, the maximum diameter is 1⅜ inch, and they are finished at the rate of 50 per hour. The material is cast iron. It is required to drill and ream a hole 23/64 inch in diameter: chamfer the outside of one end; turn a ⅝-inch diameter for a distance of 1⅜ inch, and face the side of the shoulder adjacent to this turned section. A second chamfering operation is performed on the opposite end of the piece, but this tool lay-out refers simply to the first operation. At the first spindle position, the piece is spot-centered, the end chamfered, and the outside turned for half its length. At the second spindle position, one-third of the length of the hole is drilled, the remainder of the ⅝-inch section is turned and the flange rough-faced. At the third spindle position, another third of the 23/64-inch hole is drilled and the flange is finished-faced. At the fourth spindle position, the remainder of the hole is drilled. At the fifth spindle position, the full length of the hole is reamed thus completing the operations on the piece.

NEW BRITAIN ADJUSTABLE DRAFTING TABLE

The drafting table illustrated herewith is a high-grade design having both vertical and angular adjustments. The front and side views clearly show the construction. The board

New Britain Adjustable Drafting Table

measures 36 by 48 inches and is equipped with a Keuffel & Esser parallel attachment. The board is firmly secured to cast brackets which are pivoted to the vertical supporting mem-

bers. The table is rigidly held in an angular position by tightening the hand lever shown in the view to the right. This lever binds against a segment of the supporting bracket and it is threaded to a long bolt, the head of which clamps the bracket on the opposite side. The table is adjusted vertically by the handwheel shown. This wheel is mounted on a cross shaft having pinions at each end, which engage teeth cut on the supporting legs. This table is a product of the New Britain Machine Co., 64 Bigelow St., New Britain, Conn.

BESLY 53-INCH VERTICAL-SPINDLE DISK GRINDER

A vertical-spindle disk grinder manufactured by Charles H. Besly & Co., Chicago, Ill., is shown in the accompanying illustrations. This machine is intended for "jointing or flatting" such work as stove doors, foundry flasks, meter cases, large gear cases, split shafting bearings, etc., or for other parts which do not have to be ground to a given size or angle. The work is laid on the horizontal disk wheel and is ground by gravity feed. Where work is too light to be ground satisfactorily by its own weight, the practice is to lay on weights. As many parts as the disk wheel will accommodate can be ground simultaneously. As soon as one piece is finished, it is taken off the wheel and immediately replaced by a rough piece. In this way the disk wheel is loaded constantly practically to its limit. When grinding castings for split shaft bearings, as many as thirty five are ground at once, and a laborer attends to the machine.

A hollow exhaust ring extends around the outer edge of the disk wheel for exhausting the grinding dust. This exhaust ring tapers from nothing to about five by five inches at the end where the exhauster is connected. This gradual increase of section is to give a uniform suction all around the disk wheel. The rear view, Fig. 2, shows the exhaust fan and the method of connecting it with the grinder. A removable guard ring which is cast in sections and projects two inches above the grinding face is provided around the disk wheel. This prevents the work from flying off the wheel while being ground, and aids in properly exhausting the grindings. Suitable wooden bars are usually secured to this guard ring as shown, to prevent the work from revolving with the grinding wheel. A section of the exhaust ring twenty-six inches wide, is removable, so that free access may be had to the edge of the disk wheel at this point, for grinding work which may have bosses or lugs projecting beyond the plane of the ground surface. This feature is very desirable, especially on stove work.

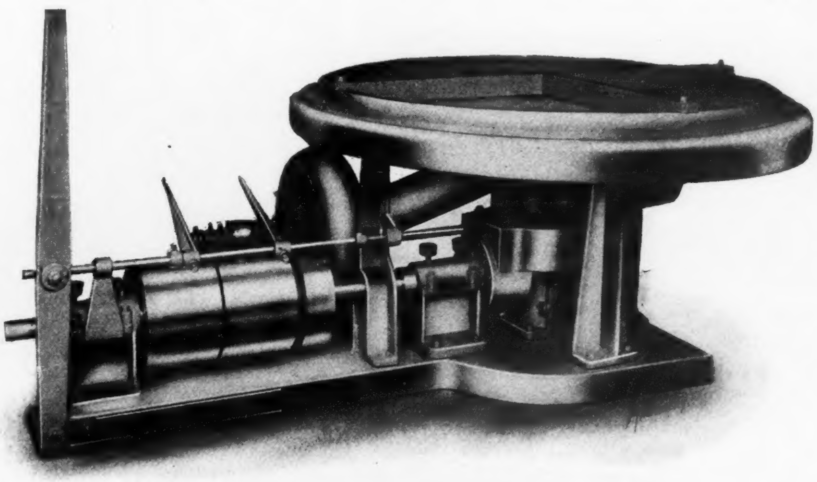


Fig. 1. Besly 53-inch Vertical-spindle Disk Grinder

The disk wheel is of wrought steel, 53 inches diameter by $1\frac{1}{4}$ inch thick. It is machined on both sides so that both faces of the wheel can be set up with circles. When the circle on one face is worn out, the disk wheel can be turned over and the opposite circle used. The machine is usually furnished with an extra steel disk wheel. A suitable press is also provided so that one wheel can be "set up" while the other is in use on the grinder. In this way the grinder can be operated continuously. The disk wheels weigh 800 pounds each. For convenience in handling, they are drilled and tapped to receive eye-bolts for connecting to a crane or hoist hook. The grinder and press are usually served by a chain hoist suspended from a suitable trolley.

The bevel gears for transmitting power from the horizontal driving shaft to the vertical spindle, are fully enclosed in a cast-iron gear case and run immersed in oil. All bearings are bushed. The tight-and-loose pulleys on the horizontal driving shaft are twelve inches in diameter and take an eight-inch belt. A countershaft is not necessary, as the machine can be driven direct from a lineshaft or motor located above or below it. A suitable pulley for driving the exhauster can be mounted on the horizontal shaft as shown in Fig. 1. The grinder is thirty-four inches high and weighs, complete with two disk wheels and a press, 6000 pounds.

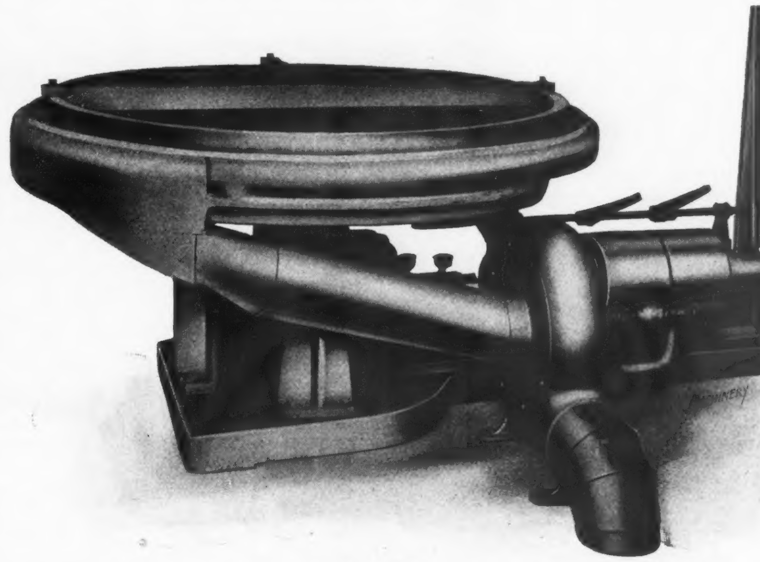


Fig. 2. Rear View of Vertical Disk Grinder, showing Exhaust System

On work for which it is adapted, this grinder is very efficient as is indicated by the following examples. When jointing cast-iron split shaft bearings, this 53-inch grinder does the work six times faster than was accomplished with two milling machines operated by one man. For facing narrow ribs on cast-iron boxes so large that a 53-inch disk wheel accommodates only four boxes at a time, the 53-inch machine does the work twenty times faster than by the profiling process formerly employed. For facing spots on power-pump bedplate castings measuring thirty-three inches by thirty-eight inches and weighing 115 pounds, the vertical disk grinder does the work ten times faster than by the former planing process.

INGERSOLL OPEN-SIDE HORIZONTAL-SPINDLE MILLING MACHINE

The Ingersoll Milling Machine Co., Rockford, Ill., has recently built and installed several open-side horizontal-spindle milling machines of the faceplate drive type. Fig. 2 shows the driving and operating side of this machine, and Fig. 1 is another view showing the machine in operation at the Dean Bros. steam pump works in Indianapolis.

The bed and table of this new design are of the standard planer-type construction. The table has twelve feed changes, and, in addition, a rapid power traverse in either direction, of thirty feet per minute. The feed motion for the table is transmitted through a Sellers rack and worm, the latter being immersed in oil. As the illustration shows, this machine has but

one main upright which is of heavy construction and is further stiffened by the addition of an auxiliary housing placed at right angles.

All the driving and feed gears and also the motor for driving the machine, are assembled upon the main housing. This means that the machine can be entirely controlled from the operator's working position. Perhaps the most interesting mechanical feature of the machine is the saddle. This is an entirely new construction. The main driving gear for the spindle, instead of transmitting the power through the spindle, delivers the full power of the machine directly to the cutter through a hardened steel driving pinion. The function of the spindle, in such a case, is simply that of supporting the driving gear, this being the arrangement when cutters of from 18 to 36

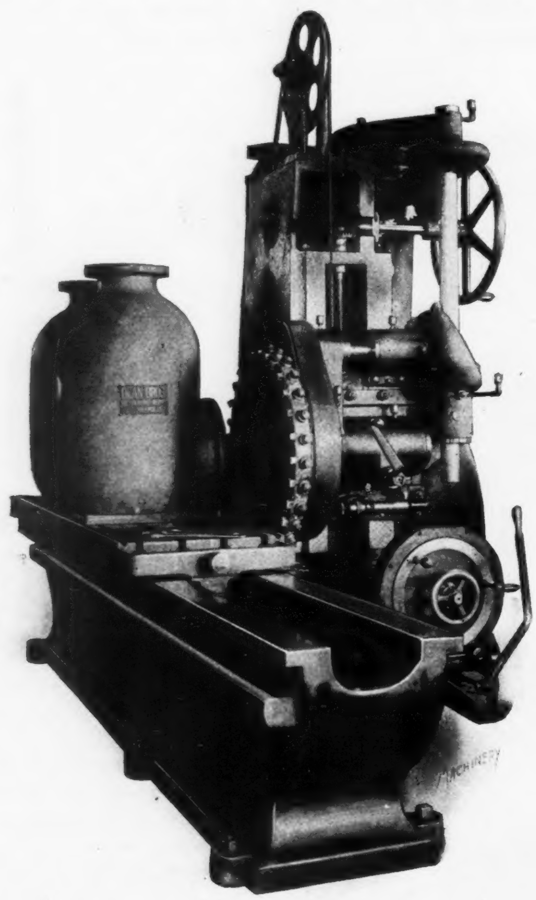


Fig. 1. Ingersoll Machine Milling Flanges of Steam Pump Air Chambers

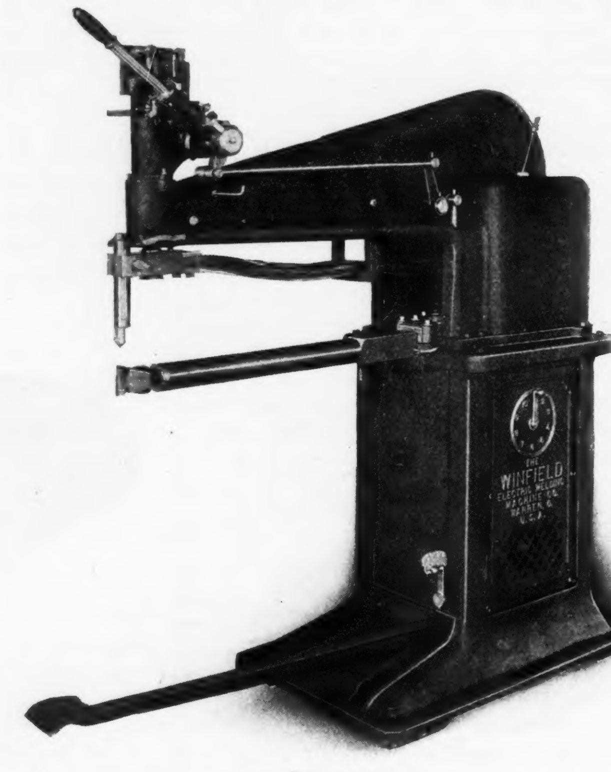
inches in diameter are used. The cutters of smaller diameter are attached to the spindle by means of a shank and draw-in bolt, and the machine is driven by the main spindle gear.

The saddle has an in-and-out adjustment by hand, and in order to provide a fine adjustment, it is equipped with a patented micrometer stop. This stop gives accurate adjustments for any position within the travel of the saddle, so that cutters as large as 36 inches in diameter can be adjusted to a thousandth of an inch, just as easily as smaller cutters on a small tool-room milling machine.

WINFIELD ELECTRIC WELDING MACHINE

The Winfield Electric Welding Machine Co., of Warren, Ohio, is the manufacturer of the 36-inch spot welder shown herewith. This is a special design particularly adapted to the spot welding of pipe. It has a capacity for stock up to 1/4 inch in thickness, and pipes ranging from 3 inches in diameter and up can be welded.

There is a swiveling head and a combination double-pole, non-arcing, automatic switch and circuit cut-out. The one-inch welder points are water cooled. In addition to a hand lever, the machine is equipped with a removable, adjustable foot-treadle having a stop. The transformer has a capacity for 16 kilowatts, and a single-phase alternating current is used. The voltage is regulated by a 10-point, self-contained regulator having an indicating dial at the side of the column, as shown.



Winfield Pipe Spot Welding Machine

This welder has an overhang of 36 inches and a die opening of 3 inches. The distance between the horns is 8 inches. The height from the floor to the center of the dies is 43 1/2 inches. The lower horn is round and has a diameter of 2 3/4

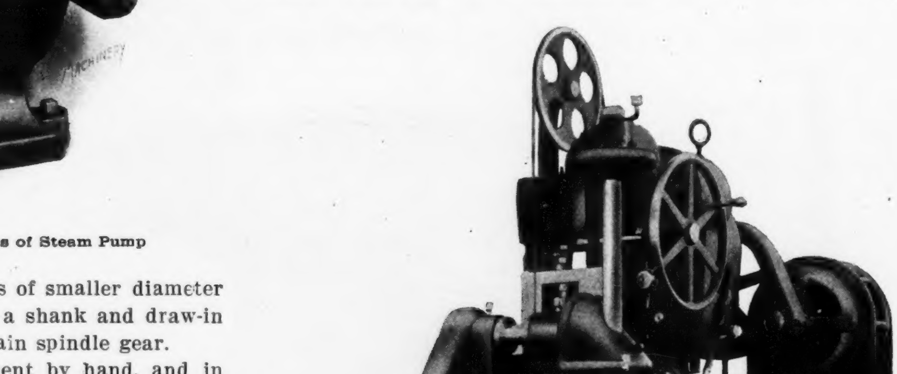


Fig. 2. Ingersoll Open-side Horizontal-spindle Milling Machine

inches. The welder requires a floor space of 26 by 42 inches, and its net weight is 2100 pounds.

* * *

A hexagon nut should always be used wherever the movement of the wrench is limited.

NEW MACHINERY AND TOOLS NOTES

Die-Stock: J. M. Carpenter Tap & Die Co., Pawtucket, R. I. Die-stock having holes in the handle which act as guides for the work. Twenty-two sizes of dies can be used in one stock.

Spacing Collar: Schuchardt & Schutte, Cedar and West Sts., New York. Adjustable spacing collar intended for spacing straddle mills. It is provided with graduations indicating an endwise movement of 0.002 inch.

Portable Grinder: Chicago Pneumatic Tool Co., Chicago, Ill. Portable pneumatic grinder which weighs 20 pounds and will take an 8 by 1 inch wheel. It is equipped with a grip handle and trigger similar to a pneumatic hammer.

Screw Driver: L. J. Watson, Port Huron, Mich. Screw driver made of spring-tempered steel and having a split end which, when pressed into the slot of a screw, holds the latter firmly while it is being entered into a hole.

Tool-holder: Double Grip Tool Co., Belleville, N. J. Tool-holder in which the cutting tool is held by a set-screw in the usual manner and also by a long gib on the top, which is forced down against the tool by the toolpost screw.

Horizontal Boring Machine: Newton Machine Tool Works, Inc., Philadelphia, Pa. Special machine for boring chords used in the construction of the new Quebec bridge. These chords have sections as large as 7 feet 10 inches, and weigh from 75 to 100 tons.

Belt Idler: Charles Miller, Industrial Bldg., Syracuse, N. Y. This idler is placed beside the driving pulley and has rollers on its periphery so that the belt can be easily shifted on or off. It is intended for use where a belt is not in continuous operation.

Tool-holder: A. O'Keefe & Sons, 353 Mulberry St., Newark, N. J. Combination tool-holder which will take three sizes of tools made of either round or square stock. The cutting tool can be held straight or tilted to the right or left for angular cutting.

Toolpost Grinder: G. Horvath, 190 Hague Ave., Detroit, Mich. Toolpost grinder consisting of an angle-plate which bolts to the tool-slide and carries the spindle head. The latter has a vertical adjustment, and can be arranged for internal as well as external grinding.

Automatic Planer Stops: Lamb Knitting Machine Co., Chicopee Falls, Mass. Two devices for automatically stopping a planer when the tool has reached a predetermined point. One stop operates by disengaging the feed gear, whereas the other shifts the belt on the countershaft.

Saw Sharpening Machine: Newton Machine Tool Works, Inc., Philadelphia, Pa. Automatic saw sharpening machine designed for either solid or inserted-tooth saw blades. The latter type are ground with the teeth in the blades, and the machine is so arranged that the rake of the teeth can be varied to suit conditions.

Multiple-Spindle Drilling Machine: Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass. Multiple-spindle drilling machine designed for drilling bolt holes in steel-tired car wheels. This is an all-geared machine, power being transmitted from the main spindle of the drill through bevel gearing and shafts, instead of universal joints. There are twelve spindles each capable of driving a $1\frac{1}{2}$-inch drill.

Convertible Open-side Planer: Detrick & Harvey Machine Co., Baltimore, Md. Open-side planing machine which may be converted into a double-housing type. The auxiliary housing is attached to the base and also at the cross-rail end by heavy bolts, and it is further secured by pockets in the base and rail end. The auxiliary housing can be quickly removed for work that cannot pass between the two housings.

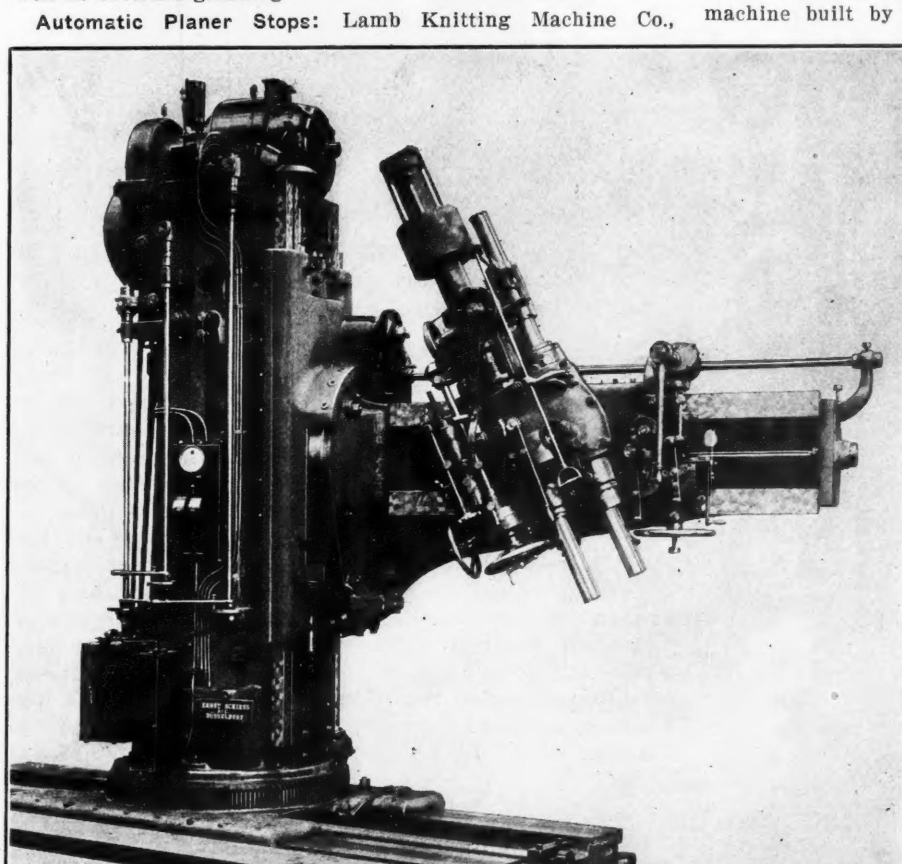
Screw-Plate: A. J. Smart Mfg. Co., Greenfield, Mass. A compact screw-plate which is only about half the size of an ordinary screw-plate of the same capacity. It is known as No. X5 and cuts threads 1/8, 5/32, 3/16, 7/32 and 1/4 inch in diameter. The stock is 5 inches long, and round adjustable dies $\frac{5}{8}$ inch in diameter are used. A tap wrench fits into the die-stock, and the entire outfit with a set of plug taps is contained in a neat and compact box.

Cylindrical Boring Machine: Automatic Machine Co., Bridgeport, Conn. Four-spindle vertical boring machine for boring and facing engine cylinders and similar work, ranging from 4 to 10 inches in diameter and having a maximum depth of 24 inches. The time required for boring and facing a cylinder $7\frac{1}{2}$ inches in diameter and 18 inches deep is $1\frac{1}{2}$ hour, but with the four spindles, all of which are in operation part of the time, the actual time per cylinder is less than thirty minutes. The boring is done in four operations, including a roughing cut, a semi-finishing cut and two finishing cuts. This machine was designed for boring cylinders with such precision that grinding would be unnecessary, and also to insure economical production by utilizing the entire time of one operator with a single machine.

* * *

RADIAL DRILLING MACHINE OF GERMAN DESIGN

The accompanying illustration shows a large radial drilling machine built by the firm of Ernst Schiess of Düsseldorf, Germany. It differs in its design considerably from the conventional type of radial drilling machine, it being entirely universal and provided with every possible adjustment; nevertheless, all the operating handwheels and levers remain close to the operator at all times. The main column is mounted on a large base-plate which is provided with ways, about 18 feet in length, on which the column can slide back and forth, this movement being actuated by an electric motor. The inner column of the upright is fixed on the slide and provided with a large spur gear at the bottom which is used for turning the whole machine around. The power for this movement is derived from the main shaft in the horizontal arm. This construction makes it possible to swing the arm through a full circle of 360 degrees.



Heavy Radial Drilling Machine of German Design

An electric motor of 18 horsepower is placed on the top of the upright. This motor is of the variable speed type (400-1200 R.P.M.), the current being carried through a sliding contact in the base-plate. The motor drives, through suitable gearing, a vertical shaft, which, in turn, transmits power to the horizontal shaft located on the arm, both shafts being provided with keyways for their full length. The vertical movement of the slide carrying the radial arm is also derived from the main vertical shaft. The motor is reversible.

All the rough or approximate adjustments of the machine are made by power, while the fine adjustments of the spindle and of the radial arm are made by handwheels and levers provided for the operator on the spindle head. Some adjustments which are very seldom required, like the swinging of the arm

from the vertical plane, or swiveling of the spindle head itself, are effected only by hand through worm and worm-gears.

The spindle is 4 5/16 inches in diameter. From the main spindle a secondary spindle is driven by spur gearing. This is used only for thread cutting. A lever in the front is provided for reversing the motion of this second spindle. The feed is provided for by a gear box giving eight changes. In addition to the power arrangement for swinging the arm around the column, a pawl and ratchet construction is used for obtaining a fine adjustment of the arm. The machine is capable of drilling holes and cutting threads up to 4 inches in diameter in armor plate, using high-speed steel drills. The spindle makes from 2 to 72 revolutions per minute, and the feed varies from 0.0035 to 0.040 inch per revolution of the spindle.

The general dimensions of the machine are as follows: The horizontal movement of the upright along the baseplate, 9 feet 10 inches; maximum height of lower end of spindle over bed, 7 feet 6 inches; minimum height of lower end of spindle, 3 feet 11 inches; maximum distance of spindle from axis of column, 10 feet 4 inches; vertical movement of drill spindle, 22 inches; vertical movement of thread-cutting spindle, 9 inches; distance between spindles, 12 inches; total weight of machine, 45 tons.

* * *

WATSON-STILLMAN CAR COUPLER SHEARING AND RIVETING PRESS

The hydraulic shearing and riveting press shown in Figs. 1 and 2 has been designed by the Watson-Stillman Co., 192

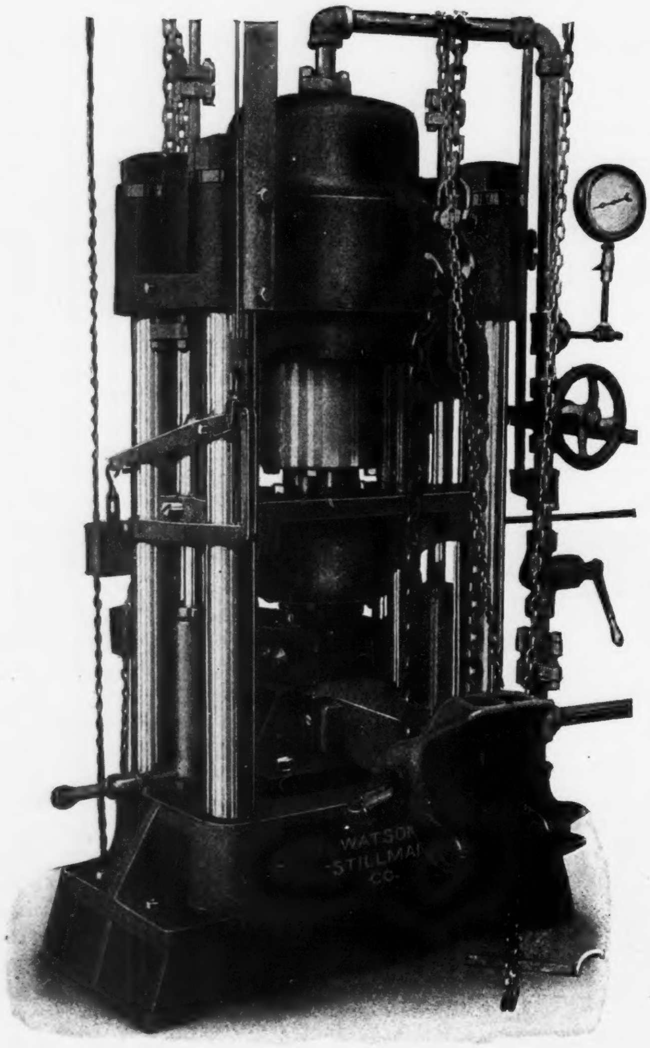


Fig. 1. Watson-Stillman Shearing and Riveting Press—View showing Coupler sheared from Yoke

Fulton St., New York, for shearing riveted coupler yokes from their couplers, and also for clamping and riveting the couplers and yokes together. Either operation is rapidly effected by a single stroke of the ram, and the use of hydraulic power further tends toward economy, as compared with the common practice of doing this work by hand and the pneumatic hammer.

In the operation of the press, the coupler is first sheared from its yoke. The yoke is placed upon supporting blocks which the coupler shank clears, and the ram descends upon the coupler shank, thus forcing it downward and shearing both ends of the rivets. Fig. 1 shows the position of the coupler and yoke after the shearing operation is completed.

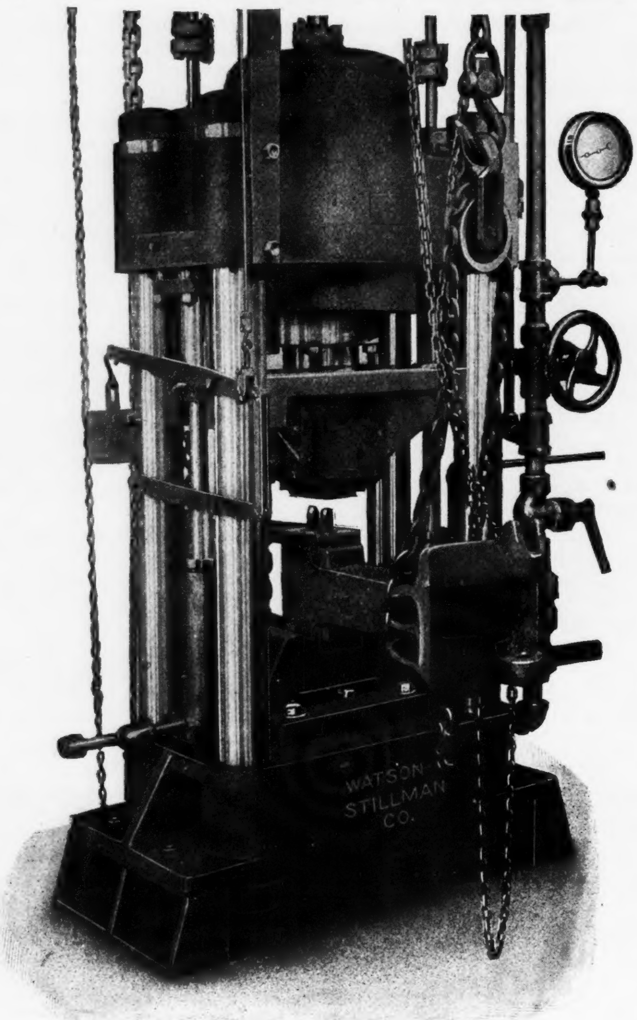


Fig. 2. Coupler and Yoke ready for Riveting

This view also indicates the method of handling the separated parts. Fig. 2 shows the coupler with the yoke and rivets attached and everything in readiness for heading the rivets. The main ram and clamping rams start downward simultaneously, the small rams first clamping the yoke to the coupler shank. The riveting die which is attached to the large ram, then descends upon the rivets and heads them.

This press is built with heavily-ribbed platens and has plenty of room for removing and replacing the work. There are two "push-back" rams for quickly and automatically returning the large ram. The diameter of the main ram is 12 inches and the stroke, 6 inches. The clamping cylinders have 3-inch rams with a 6½-inch stroke, and the push-back cylinders have 1¾-inch rams. The overall height of the press is 6 feet 8 inches; the complete weight 7858 pounds, and the capacity, 200 tons.

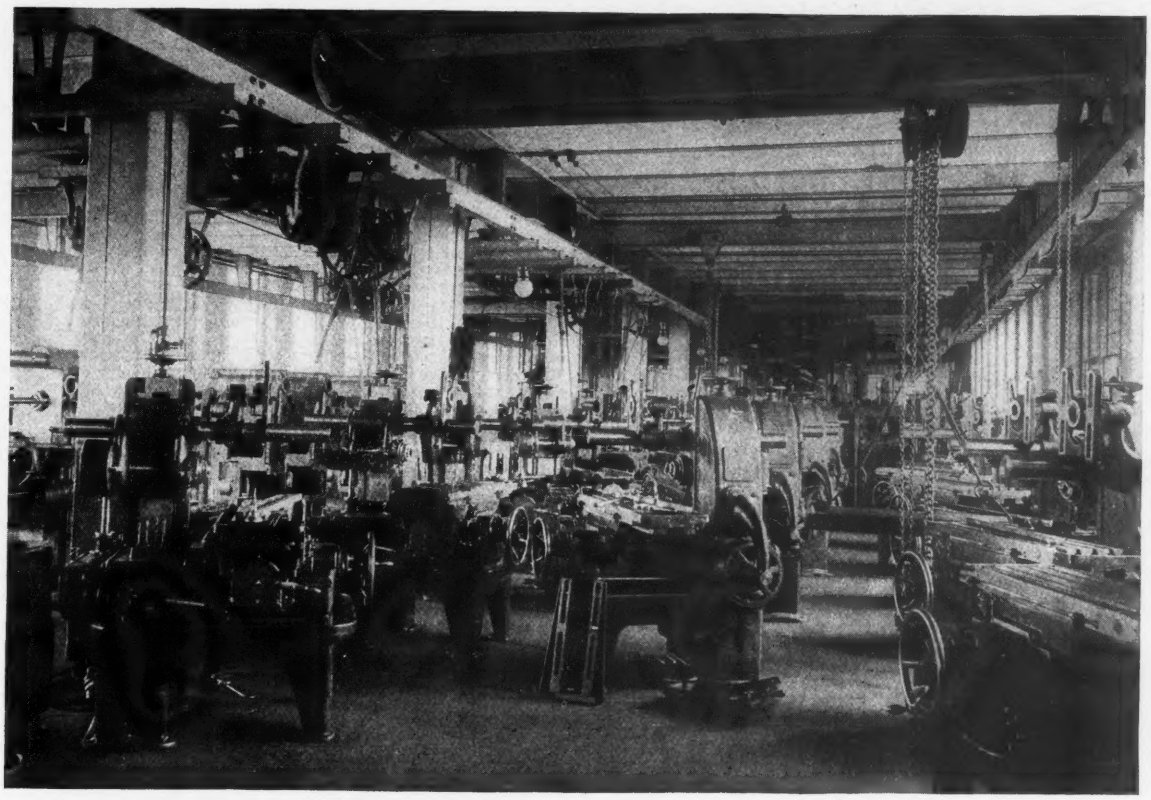
* * *

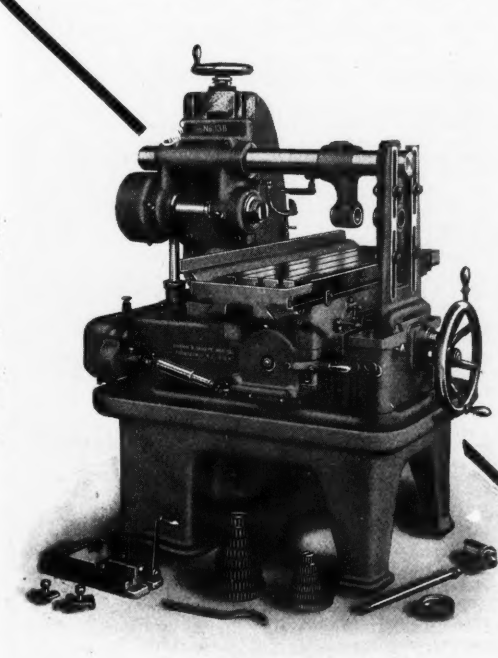
PERSONALS

William L. Wardleigh, formerly superintendent of the Baush Machine Tool Co., Springfield, Mass., is now superintendent of the Electric Goods Mfg. Co., Canton, Ohio.

Lieut.-Col. William S. Peirce of the ordnance department at Washington, D. C., has been appointed commandant of the U. S. Armory at Springfield, Mass. Col. Peirce assumes his new duties in September. He succeeds Col. Stanhope E. Blunt.

A. M. Powell, president of the Powell Machine Co., Fitchburg, Mass., left August 6 on the *Franconia* of the Cunard Line from Boston, for an extended trip abroad in the interests of his company, and for the demonstration of the Powell patent high-speed planer.





Albert S. Smith, president of the Smith & Mills Co., Cincinnati, Ohio, shaper manufacturer, returned August 24, having made a trip around the world. Mrs. Smith accompanied him.

Adolph O. Krieger has resigned his position as publicity manager of the Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo., with which he had been connected for a number of years, and has opened an office at 916 Victoria Bldg., St. Louis, for the sale of the Tacchella oil burning device.

C. J. Nyquist, superintendent of the Davis-Bournonville Co., was given a dinner by the New York officers and members of the sales force, and employes of the Jersey City shops, at Myers Hotel in Hoboken, July 17, Mr. Nyquist having returned from abroad the previous day. His trip abroad was made in the interests of his employers. He visited several cities in Germany, Denmark and France, investigating the progress being made in oxy-acetylene welding.

* * *

OBITUARIES

Harold R. Walker, secretary of the Union Caliper Co., Orange, Mass., died at his home, July 24.

Emil Von Wyck, of the Von Wyck Machine Tool Co., Cincinnati, Ohio, died suddenly in his office, July 11, aged forty-seven years.

Baxter B. Noyes, senior member of the firm of B. B. Noyes & Son, Greenfield, Mass., manufacturers of hardware specialties, small tools, blacksmiths' machinery and iron castings, died July 22, aged sixty-eight years, as the result of an accident, Mr. Noyes having fallen from a staging in the factory.

Joseph LeConte Davis, engineer in charge of design of direct-current railway type motors in the electric railway department of the Westinghouse Electric & Mfg. Co., recently deceased, was a graduate from the University of South Carolina in 1897 with the degree of electrical engineer. He was professor of physics at Bingham Academy High School, North Carolina from 1897 to 1900, and in 1904 was employed by the General Electric Co., Schenectady, N. Y. He was also at one time in charge of the developments of the National Electric Signalling Co., which embraces the Fessendon wireless system. Since 1904 Mr. Davis was with the Westinghouse Electric & Mfg. Co. He was regarded as one of the brightest and most promising of the younger electrical engineers of the present day. His work in connection with the design of the direct-current motors used on the Pennsylvania terminal electrification in Greater New York and many other large installations brought him into prominence before the electrical profession.

Charles A. Haney, vice-president and general manager of the Sloan & Chace Mfg. Co., Ltd., Newark, N. J., died after a brief illness August 10. Mr. Haney was born in Brooklyn, N. Y., July 27, 1867. He started to learn his trade with George Griswold, New Haven, Conn., at the age of fourteen years. From this time and until he became connected with the Sloan & Chace Mfg. Co. he was employed by a number of different manufacturing concerns as toolmaker, foreman and assistant superintendent. Among these concerns may be mentioned the Yost Typewriter Co., Bridgeport, Conn., the Mergenthaler Linotype Co., Brooklyn, N. Y., and the S. S. White Dental Mfg. Co., Staten Island, N. Y. At one time he was employed by Thomas A. Edison on making the early models of the phonograph. In 1902 he became general manager, vice-president and principal owner of the stock of the Sloan & Chace Mfg. Co. Through Mr. Haney's efforts and untiring energy the plant of this company was remodeled, new machinery replacing the older types, and the business grew considerably in volume, necessitating, in 1906, new and more spacious quarters. Mr. Haney was the inventor of a cyclometer and a typographical numbering machine. His unusually varied experience enabled him to successfully handle all kinds of mechanical problems. He was a member of the National Metal Trades Association, the National Machine Tool Builders' Association, and the Newark Board of Trade, as well as of a number of other organizations. He is survived by a wife and two children.

* * *

COMING EVENTS

September 2-7—Sixth congress of the International Association for Testing Materials at the Engineering Societies Building, 29 W. 39th St., New York. H. F. J. Porter, secretary, 1 Madison Ave., New York.

September 9-11.—Ninety-third meeting of the National Association of Cotton Manufacturers at the Griswold, Eastern Point, New London, Conn. C. J. H. Woodbury, secretary, Boston, Mass.

September 24-26.—Annual convention of the American Foundrymen's Association and allied bodies, in Buffalo, N. Y.; Hotel Statler, headquarters. Richard Moldenke, Watchung, N. J., secretary.

September 30-October 4.—Autumn meeting of the Iron and Steel Institute at Leeds, England. G. C. Lloyd, secretary, 28 Victoria St., London.

October 4-26.—International Machinery Exhibition at Olympia, London, England, organized by the Machine Tool and Engineering Association, Ltd.

October 7-11.—Annual convention of the American Electric Railway Association and allied associations in Chicago, Ill. The exhibit will be at Dexter Pavilion, 43d and Halstead Sts. H. C. Donecker, secretary-treasurer, 29 W. 39th St., New York.

October 16-18—Annual convention of the National Machine Tool Builders' Association in New York; headquarters, Hotel Astor. James H. Herron, general manager, Cleveland, Ohio.

SOCIETIES, SCHOOLS AND COLLEGES

Newberry College, Newberry, S. C. Catalogue for 1911-1912, containing 80 pages, 6 by 9 inches, of information relating to the departments and courses of instruction of the college. The catalogue is illustrated with a number of halftones showing the various buildings, as well as interior views.

American Society of Swedish Engineers, 271 Hick St., Brooklyn, N. Y., announces two lectures for its meetings during September. On Sept. 7 at 8:30 P. M., Mr. L. Pelletier, advertising representative of Machinery, will speak on "Advertising in Its Relation to Engineering." On September 21, Mr. C. J. Nyquist, superintendent of the Davis-Bournonville Co., will speak on "Oxy-Acetylene Welding and Its Applications." Mr. Nyquist will be assisted by a demonstrator who will show the oxy-acetylene welding and cutting apparatus in action.

National Metal Trades Association, New England Bldg., Cleveland, Ohio. Pamphlet entitled "Industrial Betterment Activities of the National Metal Trades Association." The pamphlet outlines the history of the society and its constructive activities along the lines of industrial education, apprenticeship systems, cooperative profit-sharing plans, safety appliances, hygiene and sanitation, systematic compensation for industrial accidents, legislation, extension of transportation facilities and local branches and employment bureaus. It should be of interest to manufacturers generally, whether members of the association or not.

Iowa State College, Ames, Iowa, announces that two new scholarships have been established in agricultural engineering, one being founded by the M. Rumely Co., of Laporte, Ind., and the other by the International Harvester Co., of Chicago, Ill. These scholarships are intended for young men qualified to do special research work along the lines of agricultural engineering, and amount to $250 a year each. They were established at the Iowa State College on account of the fact that this college was the first to institute a four-year course in agricultural engineering, and because instruction in this branch of engineering has been most highly developed at this college.

American Society of Engineer Draftsmen, 116 Nassau St., New York, held its regular monthly meeting in the Engineering Societies Building, Thursday, August 15. A paper was read by Mr. W. T. Walters of Chicago, on "Safety Devices—Their Application and Design." Prof. Charles W. Weick of Columbia University spoke on "Practical Perspective," and the question of whether to place dimension figures on drawings perpendicular to the bottom of the drawing or perpendicular to the dimension line was discussed. The general opinion seemed to be that the figures should be placed perpendicular to the dimension line. The American Museum of Safety, which adjoins the society's meeting room, was thrown open for the evening to members and visitors, and an opportunity was afforded to inspect the collection of the museum.

NEW BOOKS AND PAMPHLETS

Report of the Commissioner of Education for the Year Ended June 30, 1911. Volume II. 1407 pages, 6 by 9 inches. Published by the Department of the Interior, Washington, D. C.

The Physical Testing of Rock for Road Building. By Albert T. Goldbeck and Frank H. Jackson. 96 pages, 6 by 9 inches. Published by the U. S. Department of Agriculture, Washington, D. C.

Railroad Operating Costs. By Suffern & Son. Volume II. 144 pages, 8 by 11 inches. Published by Suffern & Sons, New York. Price $2.

This volume includes the reports on the operations of railways for 1911, and comprises a continuation of studies in operating costs of the leading American railroads, undertaken by the authors. The book is divided into eight chapters, of which the first is of a general introductory character; the second deals with the maintenance of way and structures; the third with maintenance of equipment; the fourth with freight car maintenance; the fifth with locomotive maintenance; the sixth with passenger car maintenance; the seventh with transportation expenses; and the eighth with fuel. The last chapter gives exhaustive information about the cost and amount of fuel required under various conditions.

Hendricks' Commercial Register of the United States. 1574 pages, 7½ by 10 inches. Published by S. E. Hendricks Co., New York. Price, $10.

This is the twenty-first annual edition of this most useful book for buyers and sellers in the architectural, mechanical engineering, contracting, electrical, railroad, iron, steel, hardware, mining, milling, quarrying, exporting and kindred industries. The aim of the book is to furnish a complete classification list of manufacturers of various products for the benefit of those who want to buy as well as for those who want to sell. It contains over 350,000 names and addresses of manufacturers and dealers, arranged under nearly 40,000 business classifications. One of the main features of this book is the complete index of classifications included, which covers 122 pages with about 350 classifications on each page. The most important and valuable feature of this commercial register, outside of its unusual completeness, is the simplicity of its classifications, making it possible to locate a manufacturer of any product very quickly. Another valuable feature is that the trade names of all articles classified in the book have been included as far as it has been possible to secure them. These trade names appear in parentheses between the names and addresses of the manufacturers under the classifications where they appear. The new edition has been considerably enlarged, an addition of 155 pages having been made. As there are 230 pages of concellations, etc., omitted from the present edition, there is a total of 385 pages of new matter. The book should prove very useful to any business firm who has dealings with manufacturers or dealers in any of the lines mentioned above.

NEW CATALOGUES AND CIRCULARS

Standard Mfg. Co., Bridgeport, Conn., manufacturer of gear cutting machines, has issued a new catalogue.

Emerson Electric Mfg. Co., St. Louis, Mo. Bulletin No. 3711 on laboratory lathes for alternating and direct currents.

Temco Electric Motor Co., 99 Sugar St., Leipsic, Ohio. Folder showing applications of the Temco portable electric drill.

L. S. Starrett Co., Athol, Mass. Booklet descriptive of the Chicago store of the L. S. Starrett Co., illustrated with halftones.

Bausch & Lomb Optical Co., Rochester, N. Y. Catalogue describing large photomicrographic apparatus for laboratory work.

Bosch Magneto Co., 223-225 W. 46th St., New York. Catalogue describing the Bosch magneto ignition for one-cylinder motor-cycles.

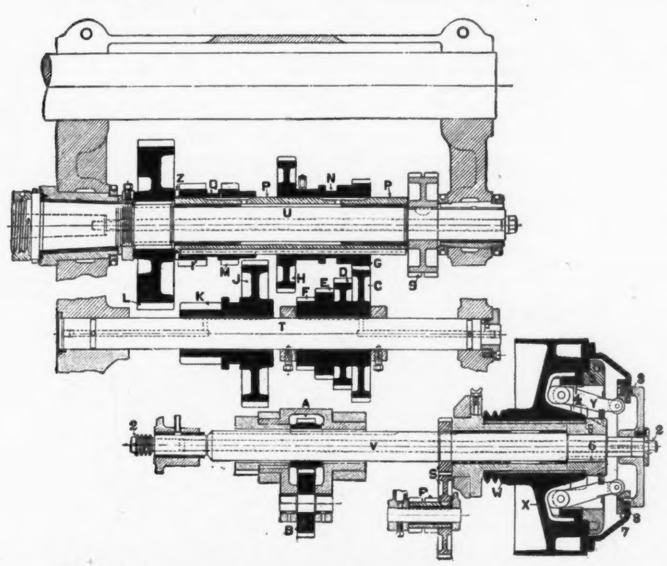
THE CINCINNATI HIGH POWER SPINDLE DRIVE

All the spindle drive gears are cut from solid steel forgings.

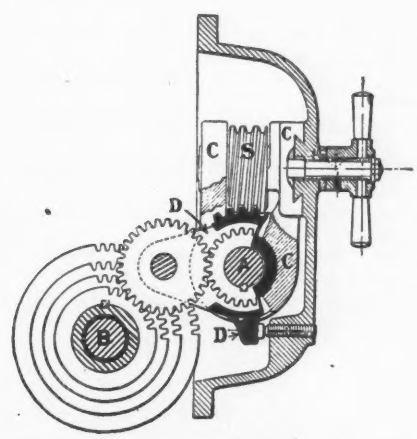
The eight that are chiefly used for speed changing—A, B, C, D, E, F, G and H—are nickel steel and hardened.

They all have stout teeth, resulting from a 20° pressure angle.

There are never any of them engaged when not required for the speed being used.



The Cincinnati gear train set for one of the eight fast speeds, which use only the tumbler gears A and B, the cone gear and G (or H). The bracket W carries the pulley and relieves shaft V of the belt pull. The tumbler gears, cone gears and sliding gears are nickel steel and hardened.



The massive tumbler frame C is clamped securely between its bearing and abutment D by screw S, at each working position.

The drive is always through the face gear "L," close to the working end of the spindle.

Neither the spindle nor any of the shafts are subjected to combined bending and torsional strains.

All shafts are supported in adequate bearings at both ends.

Because of the simplicity and rigidity of all its members the friction loss is small, and it transmits more of the power to the cutter at any speed, than others.

In other words, CINCINNATI HIGH-POWER MILLERS produce more work with the power used.

And they last longer and hold their accuracy better than others subjected to the same heavy duty of which ours are capable.

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO, U. S. A.

EUROPEAN AGENTS—Alfred H. Shutte, Cologne, Berlin, Brussels, Milan, Paris, Barcelona. Donauwerk Ernst Krause & Co., Vienna, Budapest and Prague. Sam Lagerlofs, Stockholm, Sweden. Axel Christiernsson, Abo, Finland. Chas. Churchill & Co., London, Birmingham, Manchester, Newcastle-on-Tyne and Glasgow.

CANADA AGENT—H. W. Petrie, Limited, Toronto, Montreal and Vancouver. AUSTRALIAN AGENTS—Thos. McPherson & Son, Melbourne.

JAPAN AGENTS—Andrews & George, Yokohama. CUBA AGENT—Krajewski-Pesant Co., Havana.

ARGENTINE AGENTS—Robert Pusterla & Co., Buenos Aires.

CONTENTS FOR SEPTEMBER

The first column of page numbers applies to the Engineering and Railway Editions: the second to the Shop Edition.

KERR TURBINE Co., Wellsville, N. Y. Bulletin No. 26 describing the "Economy" steam turbine. Steam consumption curves are shown and size comparisons made.

FULTON MACHINE & VISE Co., Lowville, N. Y. 1912 catalogue of vises and centrifugal pumps. The catalogue illustrates and describes the Star, Peerless, F. & R., and Fulton types of vises.

BEAUDRY & Co., 141 Milk St., Boston, Mass. Catalogue of "Beaudry" power hammers comprising the Beaudry Champion, 50- to 500-pound rams, and the Beaudry Peerless, 25- to 200-pound ram.

SPRAGUE ELECTRIC WORKS OF GENERAL ELECTRIC Co., 527-531 W. 34th St., New York. Bulletin No. 902 describing and illustrating Sprague electric grab-bucket cranes, and showing examples of their use.

GOULD & EBERHARDT, Newark, N. J. Circular illustrating and describing the "Invincible Type" 24 inch shaper, designed to take care of extra heavy work required in steel mills, railroad shops and drop forging die shops.

AMERICAN STOKER Co., 11 Broadway, New York. Bulletin B-1, entitled "The Class 'E' Stoker," illustrating and describing in detail the devices made by the company for obtaining high efficiency in the burning of coal.

TRIUMPH ELECTRIC Co., Cincinnati, Ohio. Bulletin No. 491, describing direct-current steel frame motors. The construction of the various parts is shown in detail, and instructions for starting and operating electric motors are given.

CROCKER-WHEELER Co., Ampere, N. J. Bulletin No. 153 on direct-current lighting and power generators from 200 to 1500 kilowatts; Bulletin No. 154 on oil insulated, self-cooled and water-cooled power transformers from 50 to 5000 KVA.

GILBERT & BARKER MFG. Co., Springfield, Mass. Catalogue B of gas furnaces, showing various types of furnaces built by the company, and giving information regarding the work for which they are adapted and tables of dimensions and capacities.

AUTOGENOUS WELDING EQUIPMENT Co., 41 Bay St., Springfield, Mass. Circular containing a reprint from *The Locomotive* of an article entitled "Autogenous Welding for Repairing Boilers," together with additional material on autogenous welding.

CROCKER-WHEELER Co., Ampere, N. J. Bulletin No. 149, illustrating and describing direct-current motors and generators of 50 horsepower and larger. Details of the magnet frame, bearing brackets, armature laminations, armature and armature core are shown.

FORT WAYNE ENGINEERING & MFG. Co., Fort Wayne, Ind. Catalogue No. 2022 illustrating and describing the "Paul" non-storage system of water supply, pumping water direct from well; Catalogue No. 2023 on "Paul" pneumatic systems of water supply.

STANDARD ELECTRIC TOOL Co., Cincinnati, Ohio. Bulletin G-5 on Standard high-power small portable electric grinders, including tool-post electric grinders, parallel grinders and bench grinders; Bulletin No. D-6 of Standard high-power ball-bearing electric drills.

AMERICAN BLOWER Co., Detroit, Mich. Bulletin No. 324, "The 'A B C' High-pressure Exhaust Fan, Type P"; Bulletin No. 344, "The 'A B C' Cast-iron Blowers and Exhaust Fans, Type V"; Bulletin No. 347, "Unit Heaters," adapted to all types of factory buildings.

INDUSTRIAL INSTRUMENT Co., Foxboro, Mass. Bulletin No. 67 of differential recording gages. The bulletin shows the application of the instrument to boilers; reproductions of records made by it are included, as well as a table giving general dimensions of the device.

GENERAL ELECTRIC Co., Schenectady, N. Y. Lithographic poster in colors showing, full size, all the Edison "Mazda" lamps made by the company. The "Mazda" lamps range in capacity from 5 watts (for signs) to 500 watts (used for street lighting, railway terminals, etc.).

HESS-BRIGHT MFG. Co., 17 E. Erie Ave., Philadelphia, Pa. Data sheets: No. 47A, Thrust Collar Bearings; No. 59A, Driving Clutch Thrust Bearings; No. 82, Ball Bearings in Horse Vehicles; Nos. 83, 84 and 85, Ball Bearing Mountings for Vertical Armature Shafts of Electric Motors.

A. J. KELTING ENGINEERING WORKS, 459 Carroll St., Brooklyn, N. Y. Catalogue entitled "Positive Pressure Blowers," containing a comparison of the different methods of moving air for high, low and intermediate pressures, and a complete description of the Kelting pressure blowers.

WATSON-STILLMAN Co., 192 Fulton St., New York. Catalogue No. 87 describing and illustrating hydraulic coupler yoke shearing and riveting press. This type of machine shears riveted coupler yokes from their couplers or clamps and rivets the couplers and yokes together with a single stroke of the ram.

DAYTON PUMP & MFG. Co., Dayton, Ohio. Bulletin No. 15 illustrating and describing duplex double-acting power pumps and water supply systems for service conditions where the vertical suction lift does not exceed twenty feet. These pumps are built in twelve sizes, with capacities from 3 to 60 gallons per minute.

EUGENE DIETZGEN Co., 214-220 E. 23rd St., New York. Circular of the "Premier" ellipsograph for drawing ellipses and circles. The instrument is adapted for either pen or pencil work and is useful for draftsmen on cams, wheel spokes, apertures, projections, etc.; also circular of the "Dietzgen" fountain ruling pen.

INGERSOLL-RAND Co., 11 Broadway, New York. Bulletin No. 8007 illustrating and describing "Little David" pneumatic drills adapted for general drilling, reaming, tapping, flue rolling and wood boring. Illustrations showing the valve action of the drill are included, as well as several halftone illustrations showing the drill in actual use.

WINTER BROS. Co., Wrentham, Mass. Catalogue No. 7 of high-speed steel taps and dies. This catalogue contains, in addition to price lists of taps and dies, considerable valuable information relating to tapping and threading, brief, concise paragraphs on such subjects as the size of taps, lead, speed of operation, lubrication, form of cutting edges, etc., being included.

BULLARD MACHINE TOOL Co., Bridgeport, Conn. Circular V-21 illustrating and describing the turret head of the Bullard vertical turret lathe. The illustrations show the construction of the turret in detail, giving the names of the various parts and describing the features of the new turret design and its advantages. An interesting record of tests for the accuracy of indexing and registry is included.

GOULD & EBERHARDT, Newark, N. J. Catalogue of high-duty automatic gear hobbing machines for spur, helical and worm gears. This catalogue contains a complete description of the design and operation of the Gould & Eberhardt automatic gear hobbing machines, as well as illustrations and specifications of the four sizes of machines built, ranging from 12 by 10 inches to 36 by 14 inches capacity.

E. HORTON & SON Co., Windsor Locks, Conn. 1912 catalogue of lathe chucks, faceplate jaws, and drill chucks. This catalogue contains illustrations and descriptions of all the chucks designed and made by the S. E. Horton Machine Co., and the E. Horton & Son Co., which are now made by the consolidated company known by the latter name. The catalogue covers a wide line of independent, universal and combination chucks, two jaw chucks, drill chucks, and planer chucks.

CLEVELAND HARDWARE Co., Cleveland, Ohio. Safety poster in English and German illustrating hospital room, caring for an emergency case, safety device for trimming presses, danger from carelessly operated trucks, lineshaft dangers; danger to female operators running drill presses, etc. The poster carries blanks to be torn off and filled out by employes whenever defects in machinery or conditions injurious to health are noted; also reports of accidents when workmen are injured.

INGERSOLL-RAND Co., 11 Broadway, New York. Catalogue form 75 entitled "Water Lifted by Compressed Air." During recent years considerable progress has been made in the development of compressed air pumping apparatus. The air lift has been found especially useful for asylums, hospitals, plantations, railway water tanks, etc. The catalogue describes the various methods employed for utilizing air for lifting water, and gives figures showing cost of operation of various installations.

NEW BRITAIN MACHINE Co., 64 Bigelow St., New Britain, Conn. Catalogue of multiple-spindle automatic chucking machines. This catalogue contains 38 pages, 9 by 12 inches, describing in detail the main features of the New Britain automatic multiple-spindle chucking machines. It is profusely illustrated with both halftones and line engravings and contains specifications and tables of capacities of the various sizes of these machines, as well as illustrations of the work for which these machines are peculiarly adapted.

WESTINGHOUSE ELECTRIC & MFG. Co., East Pittsburg, Pa., Circular No. 1516 illustrating and describing Baldwin-Westinghouse electric locomotives; Circular No. 1524 describing switchboard indicating meters; Leaflet No. 2494 describing synchronous booster rotary converters; Leaflet No. 2499 describing commutating-pole direct-current motors; Leaflet No. 2480 containing rules for the selection of machine tool motors; Leaflet No. 3505, on motors for paper mill service; Leaflets Nos. 2465 to 2471, on various kinds and types of meters.

WHITMAN & BARNES MFG. Co., Akron, Ohio. Catalogue No. 82 of twist drills, reamers, drop-forged and screw wrenches, spring cotters, flat spring and riveted keys and drill chucks. This catalogue comprises 170 pages, 6 by 9 inches, and covers completely the extensive

line of machinists' supplies manufactured by the company. Directions for drill grinding are included, as well as a number of useful tables giving speed and feed of carbon and high-speed steel drills, etc. A novel feature of the catalogue is that the prices of carbon and high-speed steel drills are given side by side on the same page, the latter being printed in red.

NEWTON MACHINE TOOL WORKS, INC., 24th and Vine Sts, Philadelphia, Pa. Catalogue No. 47 of cold saw cutting-off machines. This catalogue comprises 95 pages, 6 by 9 inches, devoted exclusively to cold saw cutting-off machines. In addition, a number of pages are inserted showing halftone illustrations of other lines of machine tools built by this company. The catalogue contains information relating to cutting compounds to be used with the machines described, and on the speed and feed to be used for various materials. The types of machines illustrated and described are as follows: Bar type saw; I-beam saws; internal cold saw cutting-off machines: combination type saw; crankshaft saw; girder rail saw; duplex type saw; steel foundry type saw; armor plate saw; and multiple cold saw cutting-off machines. In addition, the catalogue illustrates independent and automatic saw sharpening machines.

TRADE NOTES

AMERICAN EMERY WHEEL WORKS, Providence, R. I. Program of the second annual outing of the employes, held at Emery Park, Auburn, R. I., Saturday, June 22.

WELLS BROS. CO., and WILEY & RUSSELL MFG. CO., Greenfield, Mass. Program of the first annual field day of the employes of these two companies at Island Park, Brattleboro, Vt., Saturday, August 3.

Gisholt Grinder is the name of a publication issued by the employes of the Gisholt Machine Co., Madison, Wis. It is published and edited entirely by the employes of the company, and contains personal items and announcements of interest to those connected with the concern.

J. N. LAPOINTE CO., Marlboro, Mass., builder of broaching machinery, will move to New London, Conn., on October 1. A factory of concrete and brick construction, two stories high, with an ell extension, which will provide a total floor space of 20,000 square feet, is now being built.

VULCAN ENGINEERING SALES CO., Chicago, Ill., has taken the selling agency for the line of structural and plate working machinery, punches, shears, rolls, bulldozers, etc., manufactured by the Rock River Machine Co., Janesville, Wis. In addition to this line, the Vulcan Engineering Sales Co. now controls the product of the Hanna Molding Machine Works, the Mumford Molding Machine Co., and the Q. M. S. Co.

NEW DEPARTURE MFG. CO., Bristol, Conn., is building additions to its factory, which will increase the present floor space by nearly 75,000 square feet. The new additions will be available for use late in the fall of the present year. This increase in manufacturing facilities has been necessitated by the fact that the plant is at present running 127 hours a week in all departments and 152 hours a week in some departments, in order to meet the demands of the market.

DAVIS-BOURNONVILLE CO., 97 West St., New York, used oxy-acetylene cutting torches for cutting away the wrecked steel in the crushed bow of the Fall River Line steamship *Commonwealth*, which has been in dry dock at Hoboken since her recent collision with the United States battleship *New Hampshire* in Long Island Sound. The cutting required the time of several operators for two days but the oxy-acetylene torches made short work of what would otherwise have been a much more difficult task.

MISCELLANEOUS

Advertisements in this column, 25 cents a line, ten words to a line. The money should be sent with the order. Answers addressed to our care will be forwarded. Original letters of recommendation should not be enclosed to unknown correspondents.

AGENTS IN EVERY SHOP WANTED to sell my sliding calipers. Liberal commission. ERNST G. SMITH, Columbia, Pa.

DESIGNING, DETAILING and Blue Printing at reasonable rates. E. B. STAUFFER, Ephrata, Pa.

DRAFTSMEN AND MACHINISTS.—American and foreign patents secured promptly; reliable researches made on patentability or validity; twenty years' practice; registered; responsible references. EDWIN GUTHRIE, Corcoran Building, Washington, D. C.

ENGINEERS, SUPERINTENDENTS, Designers, Draftsmen, Engineering Salesmen, Production Engineers and Mechanical Foremen will find it to their advantage to investigate our method of securing employment. Unless record can stand investigation don't bother about answering this ad. THE ENGINEERING AGENCY, INC. (Est. 1893), Monadnock Block, Chicago.

FOR SALE.—All or a CONSIDERABLE PART of a $200,000.00 MANUFACTURING BUSINESS, largely in the metal line. Location the best, good buildings, well equipped with up-to-date machinery, excellent staff of skilled workmen. Unusually good relations with employees; never an hour of labor troubles. Business on a prosperous, money-making basis, built up in a few years from a very small beginning from its own profits, and capable of rapid increase in capacity and value.

Reason for selling, old age of the principal owner. On certain conditions would retain large or small part of ownership, in which case it would be deemed an advantage to have the purchase divided among a number, especially if all or part of the investors were qualified to take an active part in the work or management. Address Box 462, care MACHINERY, 49 Lafayette St., New York.

FOR SALE.—I wish to dispose of my patents, just issued, on Nut Tapping Machine. Address CARL BAERWALDE, Cleveland, Ohio.

FOR SALE.—LIBBEY 21" LATHE, with traverse of turret at 60", bore of spindle 3⅝", hole for turret 3½". Complete with pump and tool equipment for chuck work. This machine is in first-class shape. Gardam Patent Adjustable Multiple Spindle Drilling Machine, with 12 spindles, quick change all-gear drive (six changes), all-gear feed (four changes), and tapping attachment. Will drill anywhere within a maximum square or circle 12" with drills from ⅛" to ⅝". This machine has been used very little, and is in first-class shape. JAMES CUNNINGHAM, SON & CO., Rochester, N. Y.

FOR SALE.—Patent, Patterns, Drawings, cuts, and an elaborate equipment of small tools for the manufacture of the very best line of machine tools of their kind. Address Box 475, care MACHINERY, 49 Lafayette St., New York.

FOR SALE.—SHERIDAN 28 INCH PAPER CUTTER, in good condition, two knives; any reasonable offer accepted. Can be seen in operation. MACHINERY, 49 Lafayette St., New York.

FOR SALE.—Small power plants, steam or gas. Send for list. J. L. LUCAS & SON, Bridgeport, Conn.

INK WASH.—For making large erasures of black drawing ink from tracing cloth. Does not injure cloth. 1-oz. bottles 35 cents, 4-oz. bottles $1.00. Sample 20 cents. WM. G. BOND, Box 229, Wilmington, Del.

MACHINE TOOL SALESMAN FOR AUSTRIA, speaking German and Bohemian, capable of demonstrating efficiency of modern Machine Tools. Give details of past experience, state references, nationality, age, salary, etc., in applying to Box 463, care MACHINERY, 49 Lafayette St., New York.

MACHINISTS, TOOL-MAKERS, new vest-pocket book, most needed rules, tables, general and economic information. List of shops, 16 colored maps. Blank memoranda. 120 pages. In leather finished covers, 35c. WM. CUTHBERTSON, 37 Springside Avenue, Pittsfield, Mass. Agents wanted.

MAGNETOS.—Superintendent and Foremen. Simms Magneto Co. are re-opening their Bloomfield Factory, and have places open for a number of high class men of unquestioned ability. Ample financial means and efficient new management insure permanent positions. Apply by letter only to SIMMS MAGNETO CO., 1780 Broadway, New York.

PATENTS.—H. W. T. JENNER, patent attorney and mechanical expert, 608 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact cost. Send for full information. Trade-marks registered.

POSITION WANTED.—As superintendent of machine shop foundry, etc. Capable of handling a large shop on high grade work. Address Box 461, care MACHINERY, 49 Lafayette St., New York.

SALESMAN visiting the automobile and machinery manufacturing trades to take up a well introduced case hardening material adopted by leading concerns, as a side line on a commission basis. Address CASE HARDENING, care MACHINERY, 49 Lafayette St., New York.

SEND YOUR CATALOG, PLEASE.—We want latest catalogs and circulars on Machine Tools and Shop Appliances, for filing and reference. W. H. McELWAIN CO., Manchester, N. H.

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Tables for Article in this number o

GEAR RATIOS AND THEIR DECIMAL EQUIVALENTS—I

0.0167	1/60	0.0455	1/22	0.0862	5/58	0.1277	6/47	0.1698	9/53	0.2105	4/19
0.0169	1/59	0.0465	2/43	0.0870	2/23	0.1282	5/39	0.1702	8/47	0.2115	11/52
0.0172	1/58	0.0476	1/21	0.0877	5/57	0.1290	4/31	0.1707	7/41	0.2121	7/33
0.0175	1/57	0.0488	2/41	0.0882	3/34	0.1296	7/54	0.1714	6/35	0.2128	10/47
0.0178	1/56	0.0500	1/20	0.0889	4/45	0.1304	3/23	0.1724	5/29	0.2143	3/14
0.0182	1/55	0.0508	3/59	0.0893	5/56	0.1316	5/38	0.1731	9/52	0.2157	11/51
0.0185	1/54	0.0513	2/39	0.0909	1/11	0.1321	7/53	0.1739	4/23	0.2162	8/37
0.0189	1/53	0.0517	3/58	0.0926	5/54	0.1333	2/15	0.1750	7/40	0.2167	13/60
0.0192	1/52	0.0526	1/19	0.0930	4/43	0.1346	7/52	0.1754	10/57	0.2174	5/23
0.0196	1/51	0.0536	3/56	0.0937	3/32	0.1351	5/37	0.1765	3/17	0.2182	12/55
0.0200	1/50	0.0541	2/37	0.0943	5/53	0.1356	8/59	0.1778	8/45	0.2187	7/32
0.0204	1/49	0.0545	3/55	0.0952	2/21	0.1364	3/22	0.1786	5/28	0.2195	9/41
0.0208	1/48	0.0555	1/18	0.0962	5/52	0.1373	7/51	0.1795	7/39	0.2200	11/50
0.0213	1/47	0.0566	3/53	0.0968	3/31	0.1379	4/29	0.1800	9/50	0.2203	13/59
0.0217	1/46	0.0571	2/35	0.0976	4/41	0.1389	5/36	0.1818	2/11	0.2222	2/9
0.0222	1/45	0.0577	3/52	0.0980	5/51	0.1395	6/43	0.1833	11/60	0.2241	13/58
0.0227	1/44	0.0588	1/17	0.1000	1/10	0.1400	7/50	0.1837	9/49	0.2245	11/49
0.0233	1/43	0.0600	3/50	0.1017	6/59	0.1404	8/57	0.1842	7/38	0.2250	9/40
0.0238	1/42	0.0606	2/33	0.1020	5/49	0.1429	1/7	0.1852	5/27	0.2258	7/31
0.0244	1/41	0.0612	3/49	0.1026	4/39	0.1455	8/55	0.1860	8/43	0.2264	12/53
0.0250	1/40	0.0625	1/16	0.1034	3/29	0.1458	7/48	0.1864	11/59	0.2273	5/22
0.0256	1/39	0.0638	3/47	0.1042	5/48	0.1463	6/41	0.1875	3/16	0.2281	13/57
0.0263	1/38	0.0645	2/31	0.1053	2/19	0.1471	5/34	0.1887	10/53	0.2286	8/35
0.0270	1/37	0.0652	3/46	0.1064	5/47	0.1481	4/27	0.1892	7/37	0.2292	11/48
0.0278	1/36	0.0667	1/15	0.1071	3/28	0.1489	7/47	0.1897	11/58	0.2308	3/13
0.0286	1/35	0.0678	4/59	0.1081	4/37	0.1500	3/20	0.1904	4/21	0.2321	13/56
0.0294	1/34	0.0682	3/44	0.1087	5/46	0.1509	8/53	0.1915	9/47	0.2326	10/43
0.0303	1/33	0.0690	4/58	0.1091	6/55	0.1515	5/33	0.1923	5/26	0.2333	7/30
0.0312	1/32	0.0698	3/43	0.1111	1/9	0.1522	7/46	0.1930	11/57	0.2340	11/47
0.0323	1/31	0.0702	4/57	0.1132	6/53	0.1525	9/59	0.1935	6/31	0.2353	4/17
0.0333	1/30	0.0714	1/14	0.1136	5/44	0.1538	2/13	0.1944	7/36	0.2364	13/55
0.0339	2/59	0.0727	4/55	0.1143	4/35	0.1552	9/58	0.1951	8/41	0.2368	9/38
0.0345	1/29	0.0732	3/41	0.1154	3/26	0.1556	7/45	0.1956	9/46	0.2373	14/59
0.0351	2/57	0.0741	2/27	0.1163	5/43	0.1562	5/32	0.1961	10/51	0.2381	5/21
0.0357	1/28	0.0750	3/40	0.1167	7/60	0.1569	8/51	0.1964	11/56	0.2391	11/46
0.0364	2/55	0.0755	4/53	0.1176	2/17	0.1579	3/19	0.2000	1/5	0.2400	6/25
0.0370	1/27	0.0769	1/13	0.1186	7/59	0.1591	7/44	0.2034	12/59	0.2407	13/54
0.0377	2/53	0.0784	4/51	0.1190	5/42	0.1600	4/25	0.2037	11/54	0.2414	7/29
0.0385	1/26	0.0789	3/38	0.1200	3/25	0.1607	9/56	0.2040	10/49	0.2424	8/33
0.0392	2/51	0.0800	2/25	0.1207	7/58	0.1613	5/31	0.2045	9/44	0.2432	9/37
0.0400	1/25	0.0811	3/37	0.1212	4/33	0.1622	6/37	0.2051	8/39	0.2439	10/41
0.0408	2/49	0.0816	4/49	0.1220	5/41	0.1628	7/43	0.2059	7/34	0.2444	11/45
0.0417	1/24	0.0833	1/12	0.1224	6/49	0.1633	8/49	0.2069	6/29	0.2449	12/49
0.0426	2/47	0.0847	5/59	0.1228	7/57	0.1636	9/55	0.2075	11/53	0.2453	13/53
0.0435	1/23	0.0851	4/47	0.1250	1/8	0.1667	1/6	0.2083	5/24	0.2456	14/57
0.0444	2/45	0.0857	3/35	0.1273	7/55	0.1695	10/59	0.2093	9/43	0.2500	1/4

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GEAR RATIOS AND THEIR DECIMAL EQUIVALENTS—II

0.2542	15/59	0.2927	12/41	0.3390	20/59	0.3778	17/45	0.4186	18/43	0.4596	17/37
0.2545	14/55	0.2931	17/58	0.3393	19/56	0.3784	14/37	0.4194	13/31	0.4600	23/50
0.2549	13/51	0.2941	5/17	0.3396	18/53	0.3793	11/29	0.4200	21/50	0.4615	6/13
0.2553	12/47	0.2955	13/44	0.3400	17/50	0.3800	19/50	0.4211	8/19	0.4630	25/54
0.2558	11/43	0.2963	8/27	0.3404	16/47	0.3810	8/21	0.4222	19/45	0.4634	19/41
0.2564	10/39	0.2973	11/37	0.3409	15/44	0.3818	21/55	0.4231	11/26	0.4643	13/28
0.2571	9/35	0.2979	14/47	0.3415	14/41	0.3824	13/34	0.4237	25/59	0.4651	20/43
0.2581	8/31	0.2982	17/57	0.3421	13/38	0.3830	18/47	0.4242	14/33	0.4655	27/58
0.2586	15/58	0.3000	3/10	0.3429	12/35	0.3833	23/60	0.4250	17/40	0.4667	7/15
0.2593	7/27	0.3019	16/53	0.3437	11/32	0.3846	5/13	0.4255	20/47	0.4681	22/47
0.2600	13/50	0.3023	13/43	0.3448	10/29	0.3860	22/57	0.4259	23/54	0.4687	15/32
0.2609	6/23	0.3030	10/33	0.3455	19/55	0.3864	17/44	0.4286	3/7	0.4694	23/49
0.2619	11/42	0.3036	17/56	0.3462	9/26	0.3871	12/31	0.4310	25/58	0.4706	8/17
0.2632	5/19	0.3043	7/23	0.3469	17/49	0.3878	19/49	0.4314	22/51	0.4717	25/53
0.2642	14/53	0.3051	18/59	0.3478	8/23	0.3889	7/18	0.4318	19/44	0.4722	17/36
0.2647	9/34	0.3056	11/36	0.3488	15/43	0.3898	23/59	0.4324	16/37	0.4727	26/55
0.2653	13/49	0.3061	15/49	0.3500	7/20	0.3902	16/41	0.4333	13/30	0.4737	9/19
0.2667	4/15	0.3077	4/13	0.3509	20/57	0.3913	9/23	0.4340	23/53	0.4746	28/59
0.2679	15/56	0.3091	17/55	0.3514	13/37	0.3922	20/51	0.4348	10/23	0.4750	19/40
0.2683	11/41	0.3095	13/42	0.3519	19/54	0.3929	11/28	0.4359	17/39	0.4762	10/21
0.2692	7/26	0.3103	9/29	0.3529	6/17	0.3939	13/33	0.4364	24/55	0.4773	21/44
0.2703	10/37	0.3111	14/45	0.3542	17/48	0.3947	15/38	0.4375	7/16	0.4783	11/23
0.2708	13/48	0.3125	5/16	0.3548	11/31	0.3953	17/43	0.4386	25/57	0.4792	23/48
0.2712	16/59	0.3137	16/51	0.3556	16/45	0.3958	19/48	0.4390	18/41	0.4800	12/25
0.2727	3/11	0.3143	11/35	0.3559	21/59	0.3962	21/53	0.4400	11/25	0.4808	25/52
0.2745	14/51	0.3148	17/54	0.3571	5/14	0.3966	23/58	0.4407	26/59	0.4815	13/27
0.2750	11/40	0.3158	6/19	0.3585	19/53	0.4000	2/5	0.4412	15/34	0.4821	27/56
0.2759	8/29	0.3166	19/60	0.3590	14/39	0.4035	23/57	0.4419	19/43	0.4827	14/29
0.2766	13/47	0.3171	13/41	0.3600	9/25	0.4038	21/52	0.4423	23/52	0.4833	29/60
0.2778	5/18	0.3182	7/22	0.3611	13/36	0.4043	19/47	0.4444	4/9	0.4839	15/31
0.2791	12/43	0.3191	15/47	0.3617	17/47	0.4048	17/42	0.4464	25/56	0.4848	16/33
0.2800	7/25	0.3200	8/25	0.3621	21/58	0.4054	15/37	0.4468	21/47	0.4857	17/35
0.2807	16/57	0.3206	17/53	0.3636	4/11	0.4062	13/32	0.4474	17/38	0.4865	18/37
0.2812	9/32	0.3214	9/28	0.3654	19/52	0.4068	24/59	0.4483	13/29	0.4872	19/39
0.2821	11/39	0.3220	19/59	0.3659	15/41	0.4074	11/27	0.4490	22/49	0.4878	20/41
0.2826	13/46	0.3226	10/31	0.3667	11/30	0.4082	20/49	0.4500	9/20	0.4884	21/43
0.2830	15/53	0.3235	11/34	0.3673	18/49	0.4091	9/22	0.4510	23/51	0.4889	22/45
0.2833	17/60	0.3243	12/37	0.3684	7/19	0.4103	16/39	0.4516	14/31	0.4894	23/47
0.2857	2/7	0.3250	13/40	0.3696	17/46	0.4107	23/56	0.4524	19/42	0.4898	24/49
0.2881	17/59	0.3256	14/43	0.3703	10/27	0.4118	7/17	0.4528	24/53	0.4902	25/51
0.2885	15/52	0.3261	15/46	0.3714	13/35	0.4130	19/46	0.4545	5/11	0.4906	26/53
0.2889	13/45	0.3265	16/49	0.3721	16/43	0.4138	12/29	0.4561	26/57	0.4909	27/55
0.2895	11/38	0.3269	17/52	0.3725	19/51	0.4146	17/41	0.4565	21/46	0.4912	28/57
0.2903	9/31	0.3273	18/55	0.3729	22/59	0.4151	22/53	0.4571	16/35	0.4915	29/59
0.2909	16/55	0.3276	19/58	0.3750	3/8	0.4167	5/12	0.4576	27/59	0.5000	1/2
0.2917	7/24	0.3333	1/3	0.3774	20/53	0.4182	23/55	0.4583	11/24	0.5085	30/59

Contributed by G. M. Bartlett

ntitled "Selecting the Number of Teeth for Gears and Sprockets"

GEAR RATIOS AND THEIR DECIMAL EQUIVALENTS—III

0.5088	29/57	0.5435	25/46	0.5854	24/41	0.6275	32/51	0.6731	35/52	0.7111	32/45
0.5091	28/55	0.5439	31/57	0.5862	17/29	0.6279	27/43	0.6735	33/49	0.7115	37/52
0.5094	27/53	0.5455	6/11	0.5870	27/46	0.6286	22/35	0.6739	31/46	0.7119	42/59
0.5098	26/51	0.5472	29/53	0.5882	10/17	0.6296	17/27	0.6744	29/43	0.7143	5/7
0.5102	25/49	0.5476	23/42	0.5893	33/56	0.6304	29/46	0.6750	27/40	0.7167	43/60
0.5106	24/47	0.5484	17/31	0.5897	23/39	0.6316	12/19	0.6757	25/37	0.7170	38/53
0.5111	23/45	0.5490	28/51	0.5909	13/22	0.6326	31/49	0.6765	23/34	0.7174	33/46
0.5116	22/43	0.5500	11/20	0.5918	29/49	0.6333	19/30	0.6774	21/31	0.7179	28/39
0.5122	21/41	0.5510	27/49	0.5926	16/27	0.6341	26/41	0.6780	40/59	0.7187	23/32
0.5128	20/39	0.5517	16/29	0.5932	35/59	0.6346	33/52	0.6786	19/28	0.7193	41/57
0.5135	19/37	0.5526	21/38	0.5937	19/32	0.6364	7/11	0.6792	36/53	0.7200	18/25
0.5142	18/35	0.5532	26/47	0.5946	22/37	0.6379	37/58	0.6800	17/25	0.7209	31/43
0.5151	17/33	0.5536	31/56	0.5952	25/42	0.6383	30/47	0.6809	32/47	0.7222	13/18
0.5161	16/31	0.5556	5/9	0.5957	28/47	0.6389	23/36	0.6818	15/22	0.7234	34/47
0.5167	31/60	0.5577	29/52	0.5962	31/52	0.6400	16/25	0.6829	28/41	0.7241	21/29
0.5172	15/29	0.5581	24/43	0.5965	34/57	0.6410	25/39	0.6833	41/60	0.7250	29/40
0.5179	29/56	0.5588	19/34	0.6000	3/5	0.6415	34/53	0.6842	13/19	0.7255	37/51
0.5185	14/27	0.5593	33/59	0.6034	35/58	0.6429	9/14	0.6852	37/54	0.7273	8/11
0.5192	27/52	0.5600	14/25	0.6038	32/53	0.6441	38/59	0.6857	24/35	0.7288	43/59
0.5200	13/25	0.5610	23/41	0.6042	29/48	0.6444	29/45	0.6863	35/51	0.7292	35/48
0.5208	25/48	0.5614	32/57	0.6047	26/43	0.6452	20/31	0.6875	11/16	0.7297	27/37
0.5217	12/23	0.5625	9/16	0.6053	23/38	0.6458	31/48	0.6889	31/45	0.7308	19/26
0.5227	23/44	0.5636	31/55	0.6060	20/33	0.6471	11/17	0.6897	20/29	0.7317	30/41
0.5238	11/21	0.5641	22/39	0.6071	17/28	0.6481	35/54	0.6905	29/42	0.7321	41/56
0.5250	21/40	0.5652	13/23	0.6078	31/51	0.6486	24/37	0.6909	38/55	0.7333	11/15
0.5254	31/59	0.5660	30/53	0.6087	14/23	0.6491	37/57	0.6923	9/13	0.7347	36/49
0.5263	10/19	0.5667	17/30	0.6098	25/41	0.6500	13/20	0.6939	34/49	0.7353	25/34
0.5273	29/55	0.5676	21/37	0.6102	36/59	0.6512	28/43	0.6949	41/59	0.7358	39/53
0.5278	19/36	0.5682	25/44	0.6111	11/18	0.6522	15/23	0.6957	16/23	0.7368	14/19
0.5283	28/53	0.5686	29/51	0.6122	30/49	0.6531	32/49	0.6964	39/56	0.7381	31/42
0.5294	9/17	0.5690	33/58	0.6129	19/31	0.6538	17/26	0.6970	23/33	0.7391	17/23
0.5306	26/49	0.5714	4/7	0.6136	27/44	0.6545	36/55	0.6977	30/43	0.7400	37/50
0.5312	17/32	0.5741	31/54	0.6140	35/57	0.6552	19/29	0.6981	37/53	0.7407	20/27
0.5319	25/47	0.5745	27/47	0.6154	8/13	0.6562	21/32	0.7000	7/10	0.7414	43/58
0.5333	8/15	0.5750	23/40	0.6167	37/60	0.6571	23/35	0.7018	40/57	0.7419	23/31
0.5345	31/58	0.5757	19/33	0.6170	29/47	0.6579	25/38	0.7021	33/47	0.7429	26/35
0.5349	23/43	0.5763	34/59	0.6176	21/34	0.6585	27/41	0.7027	26/37	0.7436	29/39
0.5357	15/28	0.5769	15/26	0.6182	34/55	0.6591	29/44	0.7037	19/27	0.7442	32/43
0.5366	22/41	0.5778	26/45	0.6190	13/21	0.6596	31/47	0.7045	31/44	0.7447	35/47
0.5370	29/54	0.5789	11/19	0.6200	31/50	0.6600	33/50	0.7059	12/17	0.7451	38/51
0.5385	7/13	0.5800	29/50	0.6207	18/29	0.6604	35/53	0.7069	41/58	0.7455	41/55
0.5400	27/50	0.5806	18/31	0.6216	23/37	0.6607	37/56	0.7073	29/41	0.7458	44/59
0.5405	20/37	0.5814	25/43	0.6222	28/45	0.6610	39/59	0.7083	17/24	0.7500	3/4
0.5417	13/24	0.5818	32/55	0.6226	33/53						

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GEAR RATIOS AND THEIR DECIMAL EQUIVALENTS—IV

0.7561	31/41	0.7949	31/39	0.8378	31/37	0.8788	29/33	0.9189	34/37	0.9600	24/25
0.7568	28/37	0.7955	35/44	0.8387	26/31	0.8793	51/58	0.9200	23/25	0.9608	49/51
0.7576	25/33	0.7959	39/49	0.8393	47/56	0.8800	22/25	0.9211	35/38	0.9615	25/26
0.7586	22/29	0.7963	43/54	0.8400	21/25	0.8810	37/42	0.9216	47/51	0.9623	51/53
0.7593	41/54	0.7966	47/59	0.8409	37/44	0.8814	52/59	0.9231	12/13	0.9630	26/27
0.7600	19/25	0.8000	4/5	0.8421	16/19	0.8824	15/17	0.9245	49/53	0.9636	53/55
0.7609	35/46	0.8036	45/56	0.8431	43/51	0.8833	53/60	0.9250	37/40	0.9643	27/28
0.7619	16/21	0.8039	41/51	0.8437	27/32	0.8837	38/43	0.9259	25/27	0.9649	55/57
0.7627	45/59	0.8043	37/46	0.8444	38/45	0.8846	23/26	0.9268	38/41	0.9655	28/29
0.7632	29/38	0.8049	33/41	0.8448	49/58	0.8857	31/35	0.9273	51/55	0.9661	57/59
0.7636	42/55	0.8056	29/36	0.8462	11/13	0.8864	39/44	0.9286	13/14	0.9667	29/30
0.7647	13/17	0.8065	25/31	0.8475	50/59	0.8868	47/53	0.9298	53/57	0.9677	30/31
0.7660	36/47	0.8070	46/57	0.8478	39/46	0.8889	8/9	0.9302	40/43	0.9687	31/32
0.7667	23/30	0.8077	21/26	0.8485	28/33	0.8909	49/55	0.9310	27/29	0.9697	32/33
0.7674	33/43	0.8085	38/47	0.8491	45/53	0.8913	41/46	0.9318	41/44	0.9706	33/34
0.7679	43/56	0.8095	17/21	0.8500	17/20	0.8919	33/37	0.9322	55/59	0.9714	34/35
0.7692	10/13	0.8103	47/58	0.8511	40/47	0.8929	25/28	0.9333	14/15	0.9722	35/36
0.7708	37/48	0.8108	30/37	0.8519	23/27	0.8936	42/47	0.9348	43/46	0.9730	36/37
0.7714	27/35	0.8113	43/53	0.8529	29/34	0.8947	17/19	0.9355	29/31	0.9737	37/38
0.7719	44/57	0.8125	13/16	0.8537	35/41	0.8958	43/48	0.9362	44/47	0.9743	38/39
0.7727	17/22	0.8136	48/59	0.8542	41/48	0.8966	26/29	0.9375	15/16	0.9750	39/40
0.7736	41/53	0.8140	35/43	0.8545	47/55	0.8974	35/39	0.9388	46/49	0.9756	40/41
0.7742	24/31	0.8148	22/27	0.8571	6/7	0.8980	44/49	0.9394	31/33	0.9762	41/42
0.7750	31/40	0.8158	31/38	0.8596	49/57	0.8983	53/59	0.9400	47/50	0.9767	42/43
0.7755	38/49	0.8163	40/49	0.8600	43/50	0.9000	9/10	0.9412	16/17	0.9773	43/44
0.7759	45/58	0.8167	49/60	0.8604	37/43	0.9020	46/51	0.9423	49/52	0.9778	44/45
0.7778	7/9	0.8182	9/11	0.8611	31/36	0.9024	37/41	0.9429	33/35	0.9783	45/46
0.7797	46/59	0.8200	41/50	0.8621	25/29	0.9032	28/31	0.9434	50/53	0.9787	46/47
0.7800	39/50	0.8205	32/39	0.8627	44/51	0.9038	47/52	0.9444	17/18	0.9792	47/48
0.7805	32/41	0.8214	23/28	0.8636	19/22	0.9048	19/21	0.9455	52/55	0.9796	48/49
0.7812	25/32	0.8222	37/45	0.8644	51/59	0.9057	48/53	0.9459	35/37	0.9800	49/50
0.7818	43/55	0.8235	14/17	0.8647	32/37	0.9062	29/32	0.9464	53/56	0.9804	50/51
0.7826	18/23	0.8246	47/57	0.8654	45/52	0.9070	39/43	0.9474	18/19	0.9808	51/52
0.7833	47/60	0.8250	33/40	0.8667	13/15	0.9074	49/54	0.9483	55/58	0.9811	52/53
0.7838	29/37	0.8261	19/23	0.8679	46/53	0.9091	10/11	0.9487	37/39	0.9815	53/54
0.7843	40/51	0.8269	43/52	0.8684	33/38	0.9107	51/56	0.9492	56/59	0.9818	54/55
0.7857	11/14	0.8276	24/29	0.8696	20/23	0.9111	41/45	0.9500	19/20	0.9821	55/56
0.7872	37/47	0.8286	29/35	0.8704	47/54	0.9118	31/34	0.9512	39/41	0.9825	56/57
0.7879	26/33	0.8293	34/41	0.8710	27/31	0.9123	52/57	0.9524	20/21	0.9828	57/58
0.7885	41/52	0.8298	39/47	0.8718	34/39	0.9130	21/23	0.9535	41/43	0.9831	58/59
0.7895	15/19	0.8302	44/53	0.8723	41/47	0.9138	53/58	0.9545	21/22	0.9833	59/60
0.7907	34/43	0.8305	49/59	0.8727	48/55	0.9143	32/35	0.9555	43/45	......	..
0.7917	19/24	0.8333	5/6	0.8750	7/8	0.9149	43/47	0.9565	22/23	......	..
0.7926	42/53	0.8364	46/55	0.8772	50/57	0.9153	54/59	0.9574	45/47	......	..
0.7931	23/29	0.8367	41/49	0.8775	43/49	0.9167	11/12	0.9583	23/24	......	..

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0.5370	$\frac{29}{54}$	0.5789	$\frac{11}{19}$	0.6200	$\frac{31}{50}$	0.6600	$\frac{33}{50}$	0.7059	$\frac{12}{17}$	0.7451	$\frac{38}{51}$
0.5385	$\frac{7}{13}$	0.5800	$\frac{29}{50}$	0.6207	$\frac{18}{29}$	0.6604	$\frac{35}{53}$	0.7069	$\frac{41}{58}$	0.7455	$\frac{41}{55}$
0.5400	$\frac{27}{50}$	0.5806	$\frac{18}{31}$	0.6216	$\frac{23}{37}$	0.6607	$\frac{37}{56}$	0.7078	$\frac{29}{41}$	0.7458	$\frac{44}{59}$
0.5405	$\frac{20}{37}$	0.5814	$\frac{25}{43}$	0.6222	$\frac{28}{45}$	0.6610	$\frac{39}{59}$	0.7083	$\frac{17}{24}$	0.7500	$\frac{3}{4}$
0.5417	$\frac{13}{24}$	0.5818	$\frac{32}{55}$	0.6226	$\frac{33}{53}$	0.6666	$\frac{2}{3}$	0.7091	$\frac{39}{55}$	0.7544	$\frac{43}{57}$
0.5424	$\frac{32}{59}$	0.5838	$\frac{7}{12}$	0.6250	$\frac{5}{8}$	0.6724	$\frac{39}{58}$	0.7097	$\frac{22}{31}$	0.7547	$\frac{40}{53}$
0.5429	$\frac{19}{35}$	0.5849	$\frac{31}{53}$	0.6271	$\frac{37}{59}$	0.6727	$\frac{37}{55}$	0.7105	$\frac{27}{38}$	0.7551	$\frac{37}{49}$

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9831	[illegible]
0.7895	$\frac{15}{19}$	0.8302	$\frac{44}{53}$	0.8723	$\frac{41}{47}$	0.9138	$\frac{53}{58}$	0.9545	$\frac{21}{22}$	0.9833	$\frac{59}{60}$
0.7907	$\frac{34}{43}$	0.8305	$\frac{49}{59}$	0.8727	$\frac{48}{55}$	0.9143	$\frac{32}{35}$	0.9555	$\frac{43}{45}$	......	..
0.7917	$\frac{19}{24}$	0.8333	$\frac{5}{6}$	0.8750	$\frac{7}{8}$	0.9149	$\frac{43}{47}$	0.9565	$\frac{22}{23}$	......	..
0.7926	$\frac{42}{53}$	0.8364	$\frac{46}{55}$	0.8772	$\frac{50}{57}$	0.9153	$\frac{54}{59}$	0.9574	$\frac{45}{47}$	......	..
0.7931	$\frac{23}{29}$	0.8367	$\frac{41}{49}$	0.8775	$\frac{43}{49}$	0.9167	$\frac{11}{12}$	0.9583	$\frac{23}{24}$	......	..
0.7941	$\frac{27}{34}$	0.8372	$\frac{36}{43}$	0.8780	$\frac{36}{41}$	0.9184	$\frac{45}{49}$	0.9592	$\frac{47}{49}$	......	..